Geosyntec consultants

TABLE OF CONTENTS

QAPP WORKSHEET #1 & 2: TITLE AND APPROVAL PAGE 1

QAPP WORKSHEET #3: DISTRIBUTION LIST 3

QAPP WORKSHEET #4: PROJECT PERSONNEL SIGN-OFF SHEET 4

QAPP WORKSHEET #5: PROJECT ORGANIZATIONAL CHART 6

QAPP WORKSHEET #6: COMMUNICATION PATHWAYS 7

QAPP WORKSHEET #7: PERSONNEL RESPONSIBILITIES AND QUALIFICATIONS 10

QAPP WORKSHEET #8: SPECIALIZED PERSONNEL TRAINING REQUIREMENTS TABLE 11

QAPP WORKSHEET #9: PROJECT PLANNING SESSION SUMMARY 12

QAPP WORKSHEET #10: CONCEPTUAL SITE MODEL 14

QAPP WORKSHEET #11: PROJECT/DATA QUALITY OBJECTIVES 15

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA 18

QAPP WORKSHEET #13: SECONDARY DATA USES AND LIMITATIONS 28

QAPP WORKSHEET #14 & 16: SUMMARY OF PROJECT TASKS AND SCHEDULE 29

QAPP WORKSHEET #15: PROJECT ACTION LIMITS AND LABORATORY-SPECIFIC DETECTION/QUANTITATION LIMITS 34

QAPP WORKSHEET #17: SAMPLING DESIGN AND RATIONALE 36

QAPP WORKSHEET #18: SAMPLING LOCATIONS AND METHODS 39

QAPP WORKSHEET #19: ANALYTICAL SOP REQUIREMENTS TABLE 40

QAPP WORKSHEET #20: FIELD QC SUMMARY 42

QAPP WORKSHEET #21: FIELD SOPS 45

QAPP WORKSHEET #22: FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION 47

QAPP WORKSHEET #23: ANALYTICAL SOPS 50

QAPP WORKSHEET #24: ANALYTICAL INSTRUMENT CALIBRATION 53

QAPP WORKSHEET #25: ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION 60

QAPP WORKSHEET #26: SAMPLE HANDLING, CUSTODY, AND DISPOSAL 63

QAPP WORKSHEET #27: SAMPLE CUSTODY REQUIREMENTS 65

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION 68

QAPP WORKSHEET #29: PROJECT DOCUMENTS AND RECORDS 85

QAPP WORKSHEET #30: ANALYTICAL SERVICES 88

QAPP WORKSHEET #31: PLANNED PROJECT ASSESSMENTS 90

QAPP WORKSHEET #32: ASSESSMENT FINDINGS AND CORRECTIVE ACTION RESPONSES 91

QAPP WORKSHEET #33: QA MANAGEMENT REPORTS TABLE 95

QAPP WORKSHEET #34: DATA VERIFICATION AND VALIDATION INPUTS 97

QAPP WORKSHEET #35: DATA VERIFICATION PROCEDURES 101

QAPP WORKSHEET #36: DATA VALIDATION PROCEDURES 105

QAPP WORKSHEET #37: DATA USABILITY ASSESSMENT 107

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QAPP WORKSHEET #1 & 2: TITLE AND APPROVAL PAGE

QUALITY ASSURANCE PROJECT PLAN

Shieldalloy Metallurgical Corporation Superfund Site
Operable Unit 3
Perchlorates

Prepared for:
Shieldalloy Metallurgical Corporation
35 South West Boulevard
Newfield, New Jersey 08344

Project JR0241

Prepared by:

Geosyntec consultants
engineers | scientists | innovators

1750 American Boulevard
Suite 200
Pennington, New Jersey 08534
(609) 895-1400

QAPP WORKSHEET #1 & 2: TITLE AND APPROVAL PAGE (CONTINUED)

Review Signatures: _____

John Persico, P.G. / Date: _____
Project Director– Geosyntec

_____
Seth Kellogg / Date: _____
Project Manager – Geosyntec

_____
Livia Capaldi / Date: _____
Quality Assurance Manager – Geosyntec

Approval Signatures: _____

Remedial Project Manager – USEPA Region 2

Plans and Reports from Previous Investigations:

TRC. 2008. *Draft Final Perchlorate Remedial Investigation Work Plan.*
TRC. 2011. *OU1 Supplemental Remedial Investigation Report.*
TRC. 2013. *Final OU3 Screening Level Ecological Risk Assessment.*
TRC. 2014. *Draft Final OU3 Human Health Risk Assessment.*
TRC. 2015 *Final Draft OU1 Feasibility Study.*
TRC. 2016. *Remedial Investigation Report.*
USEPA. 2015. *Record of Decisions Amendment. Operable Unit #1 ShieldAlloy Metallurgical Corporation, Newfield, Gloucester County, New Jersey.*

QAPP WORKSHEET #3: DISTRIBUTION LIST

QAPP Recipients	Title	Organization	Telephone Number	E-mail Address
John Persico	Project Director	Geosyntec	(609) 895-1400	JPersico@geosyntec.com
John Hunt	Director of Environmental Projects	Shieldalloy	(484) 582-3519	jhunt@amg-nv.com
Sherrel Henry	Remediation Project Manager	EPA	212-637-4273	henry.sherrel@epa.gov
Seth Kellogg	Project Manager	Geosyntec	(609) 895-1400	SKellogg@geosyntec.com
Dale Prokopchak	Corporate Health and Safety Officer	Geosyntec	(804) 665-2811	DProkopchak@geosyntec.com
Livia Capaldi	Project QA Manager	Geosyntec	(609) 895-1400	LCapaldi@geosyntec.com
Jessica Evans and Caroline Kellner	Field Manager/ Project EHS Officer	Geosyntec	(609) 895-1400	JMEvans@geosyntec.com CKellner@geosyntec.com
Mary Tyler	Analytical Data QA Manager	Geosyntec	(865) 291-4699	MTyler@geosyntec.com
Elizabeth Bauer	Laboratory Project Manager	Eurofins Lancaster Laboratories Environmental, LLC	(717) 556-7290	ElizabethMBauer@eurofinsUS.com
Neil Sturchio	Laboratory Director	Environmental Isotope Geochemistry Laboratory: University of Delaware	(302) 831-8706	Sturchio@udel.com

QAPP WORKSHEET #4: PROJECT PERSONNEL SIGN-OFF SHEET

Project Personnel	Organization/Title/Role	Telephone Number	Signature*	Date QAPP Read
Seth Kellogg	Geosyntec/Project Manager	(609) 895-1400		

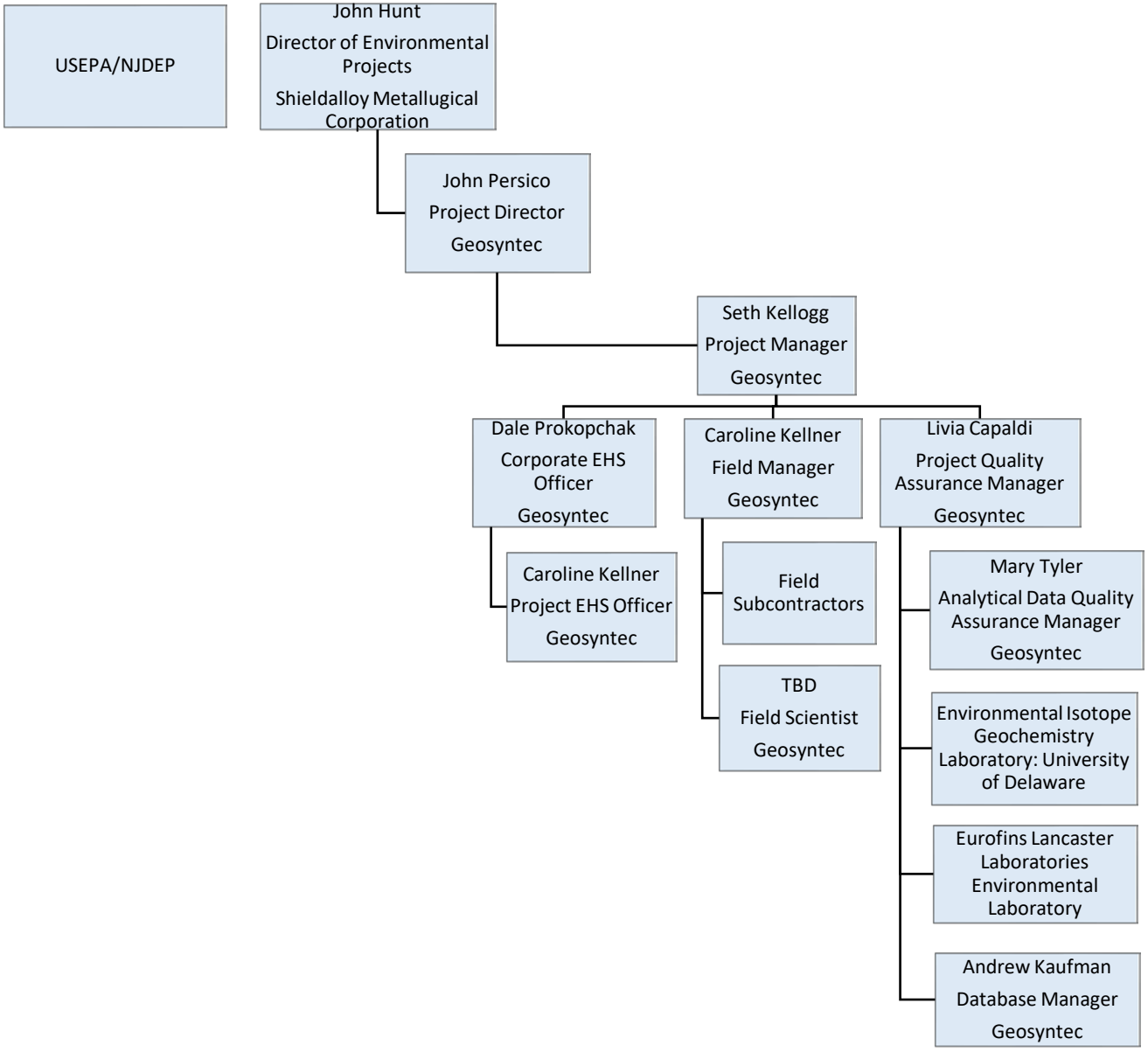
* Signature indicates personnel have read applicable QAPP sections and will perform the work as indicated herein.

Note: Additional sheets will be signed by Geosyntec field scientists and field technicians and these signatures will be maintained in the project file.

QAPP WORKSHEET #4: PROJECT PERSONNEL SIGN -OFF SHEET (CONTINUED)

Field Personnel	Organization/Title/Role	Signature*	Date QAPP Read

QAPP WORKSHEET #5: PROJECT ORGANIZATIONAL CHART



QAPP WORKSHEET #6: COMMUNICATION PATHWAYS

Communication Drivers	Responsible Affiliation	Role	Contact Information	Procedure
Approval of Amendments to QAPP	Geosyntec	Project Manager	See Worksheet #3 and #4	Obtain initial approval from Project Manager. Submit documented amendments within 10 working days for transmittal to the Respondent's Representative for submission to the EPA RPM for approval.
Approval of activities deviating from QAPP	Geosyntec	Project Manager	See Worksheet #3 and #4	Obtain initial approval from Project Manager. Submit request for deviation within 10 working days for transmittal to the Respondent's Representative for submission to the EPA Remedial Project Manager for approval.
Document Control	Geosyntec	Project Manager Project QA Manager	See Worksheet #3 and #4	The reports and formal correspondence will be reviewed by Project Manager prior to transmittal to the Respondent's Representative for submission to the EPA. Documents with analytical data prepared for submittal to EPA will be reviewed by the Project QA Manager or their designee prior to submittal to the Respondent's Representative for submission to the EPA
Stop work and initiation of stop work procedure	Geosyntec	Field Manager Project EHS Officer	See Worksheet #3 and #4	All field personnel will have stop work authority if an unsafe condition is encountered. **All stop work occurrences will be reported to the EHS Officer and the EHS Officer will forward this information on to the Project Manager using telephone and/or email as soon as possible.**
Work Stoppages	Geosyntec	Project Manager Field Manager Project EHS Officer	See Worksheet #3 and #4	The Project Manager will communicate work stoppages to the project organization within 24 hours.

QAPP WORKSHEET #6: COMMUNICATION PATHWAYS (CONTINUED)

Communication Drivers	Responsible Affiliation	Role	Contact Information	Procedure
Real time modifications, notifications, and approvals	Geosyntec	Field Manager	See Worksheet #3 and #4	Real-time modifications to the project will require the approval of the Project Manager, the Respondent's Representative and the EPA Remedial Project Manager and will be documented within 5 working days.
Reporting of health and safety issues	Geosyntec	Project EHS Officer Field Manager	See Worksheet #3 and #4	H&S issues involving an injury, a stop work procedure, a "good catch," or a condition that may result in an incident must be reported to the EHS Officer immediately. The EHS Officer will forward this information on to the Project Manager using telephone and email as soon as possible. The Project Manager will notify the Respondent's Representative and EPA Remedial Project Manager of any serious health and safety incident/issue within 24 hours of occurrence. Non-serious incidents/issues may be forwarded from the Project Manager to the Respondent's Representative and who may submit to the EPA Remedial Project Manager on a monthly basis within the monthly progress reports.
Reporting of issues related to AOC requirements.	Geosyntec	Project Manager	See Worksheet #3 and #4	Issues that prevent the collection of usable data will be reported to the Respondent Project Manager immediately.
Real time changes to sample collection or analysis procedures	Geosyntec	Field Manager Project QA Manager	See Worksheet #3 and #4	Conditions requiring variation to sampling and analysis procedures will be reported to the Field Manager within 24 hours of the condition requiring the modification. The Field Manager or Project QA Manager will report the variations to the Project Manager as appropriate.

QAPP WORKSHEET #6: COMMUNICATION PATHWAYS (CONTINUED)

Communication Drivers	Responsible Affiliation	Role	Contact Information	Procedure
Reporting issues related to data quality, including the inability to meet reporting limits	Eurofins	Laboratory PM	See Worksheet #3 and #4	Problems with the data quality will be reported to the Project Manager and Project QA Manager within 24 hours of laboratory results.
Data validation issues	Geosyntec	Analytical Data QA Manager	See Worksheet #3 and #4	Problems with data quality or data validation will be reported to the Project Manager and the QA Manager within 24 hours of the identification of the data validation issue.
Data Review Corrective Action	Geosyntec	Analytical Data QA Manager or designee	See Worksheet #3 and #4	Corrective Action Subjects: • Field Sampling Procedure • Offsite Laboratory Technical Systems Audit • Offsite Laboratory Technical Systems Audit: Laboratory Personnel • Data Quality Assessment

QAPP WORKSHEET #7: PERSONNEL RESPONSIBILITIES AND QUALIFICATIONS

Name	Project Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications
Sherrel Henry	Remedial Project Manager	EPA Region 2	Remedial Project Manager	
John Persico	Project Director	Geosyntec	Overall project direction and completion of objectives	M.S. Geology, P.G.
Seth Kellogg	Project Manger	Geosyntec	Project administration & technical oversight	M.S. Geology, P.G.
Dale Prokopchak	Health and Safety Manager	Geosyntec	Corporate health and safety management	CIH, CSP
Mary Tyler	Analytical Data Quality Assurance Manager	Geosyntec	Data validation	M.S. Engineering
Jessica Evans and Caroline Kellner	Project EHS Officer and Field Manager	Geosyntec	Site health and safety and manage field staff	M.S. Biology B.S. Geology
Livia Capaldi	Project QA Manager	Geosyntec	Project quality assurance	M.S. Geology
Elizabeth Bauer	Laboratory Project Manager	Eurofins Lancaster Laboratories Environmental	Point of contact with Geosyntec, resolve sampling, receipt, analysis and storage issues.	
Neil Sturchio	Laboratory Director	Environmental Isotope Geochemistry Laboratory: University of Delaware	Point of contact with Geosyntec, resolve sampling, receipt, analysis and storage issues.	Ph.D. Earth and Planetary Sciences

QAPP WORKSHEET #8: SPECIALIZED PERSONNEL TRAINING REQUIREMENTS TABLE

Project Function	Specialized Training by Title or Description of Course	Personnel / Groups Receiving Training	Personnel Titles / Organizational Affiliation	Location of Training Records / Certificates
Sample Collection	40-Hour HAZWOPER Training	Field Personnel	Geosyntec	Footnote 1
SOP-specific	Project-specific SOP training	Personnel as required	Geosyntec	Field Site

1. Documentation for training is maintained at home office of employee and is available upon request

QAPP WORKSHEET #9: PROJECT PLANNING SESSION SUMMARY

The following is a summary of Project Planning sessions that have occurred:

Date of Planning Session: 3/22/2019
Location: Shieldalloy Site
Purpose: Discuss project overview & technical approach

Attendees and Role:

Name	Organization	Title/ Role	Email
Jessica Evans	Geosyntec	Staff Scientist	jmevans@geosyntec.com
Sherrel Henry	EPA	Remedial Project Manager	Henry.sherrel@epa.gov
John Hunt	SMC	Respondent Project Manager	jhunt@amg-nv.com
Katherine DeLuca	EPA/ CRC	Attorney	Deluca.katherine@epa.gov
Rachel Griffiths	EPA	Hydrogeologist	Griffiths.rachel@epa.gov
Donna L. Gaffigan	NJDEP	NJDEP Case Manager	Donna.gaffigan@DEP.NJ.GOV
Seth Kellogg	Geosyntec	Project Manager	skellogg@geosyntec.com
John Persico	Geosyntec	Project Director	jpersico@geosyntec.com

Notes/Comments: Wells designated as background will need evidence to support that they are background. Several rounds of sampling will be needed to support MNA if that approach is selected.

Consensus decisions made: Project planning documents and approach are acceptable, and project planning documents should be submitted to NJDEP and EPA by 5/3/2019.

QAPP WORKSHEET #9: PROJECT PLANNING SESSION SUMMARY (CONTINUED)

Date of Planning Session: 7/30/2020
Location: Web-conference
Purpose: Discuss Alternative Groundwater Sampling Approach

Attendees and Role:

Name	Organization	Title/ Role	Email
John Persico	Geosyntec	Project Director	jpersico@geosyntec.com
Seth Kellogg	Geosyntec	Project Manager	skellogg@geosyntec.com
Jessica Evans	Geosyntec	Senior Staff Scientist	jmevans@geosyntec.com
Caroline Kellner	Geosyntec	Staff Scientist	ckellner@geosyntec.com

Notes/Comments: The Quality Assurance Project Plan (QAPP), Field Sampling Plan for OU3 Supplemental Remedial Investigation (FSP OU3 SRI) and Health and Safety Plan (HASP) will need to be revised to address the Alternative Groundwater Sampling Approach.

Consensus decisions made: Project planning documents will be revised and submitted to NJDEP and USEPA by August 13, 2020.

QAPP WORKSHEET #10: CONCEPTUAL SITE MODEL

This section presents an overview of the Conceptual Site Model (CSM) for OU3. A CSM is a representation of the physical, chemical, and biological processes that govern the transport of COCs from source(s) to receptor(s) within the system. The CSM provides a comprehensive current understanding of the sources of COCs found in groundwater at OU3, potential pathways for migration of the COCs, and potential receptors of exposure to the COCs in OU3.

While there are other COCs at the Site, OU3 addresses only the perchlorate COC in groundwater. Other Site COCs are being addressed as part of OU1 and OU2 and are not discussed in this CSM. As discussed in Section 1.2 of the Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation (Revised FSP OU3 SRI), solid potassium perchlorate was used as a catalyst in the furnace located in former Building D102(A). Unreacted slag from this process was disposed in the former lagoon and slag piles, which were possible secondary source areas for perchlorate.

The Site lies on the Bridgeton Formation (present in the eastern portion of the Site) and Cohansey Sand, which consist of sand and some silt. Groundwater is encountered at 4 to 27 ft bgs. Groundwater flow direction in both the upper and lower Cohansey Sand is southwest toward the Hudson Branch. Downward flow is restricted by the upper Kirkwood Formation which is encountered between 121 and 153 ft bgs. Historical monitoring wells are screened across the shallow, intermediate and deep zones of the aquifer to fully evaluate perchlorate concentrations.

Sampling was conducted by TRC from 2006 through 2011 to assess the distribution of perchlorate both on-Site and off-Site. Ten vertical profile borings (VP-1, VP-2, VP-3, VP-4, VP-10, VP-13, VP-13A, VP-14, VP-15, and VP-15A) were advanced and sampled to the southwest of the Site to determine the off-Site lateral and vertical extent of perchlorate. Based on the results of this sampling, seven permanent monitoring wells (SC30D, SC32D, SC33D, SC34D, SC35D, SC36D, and SC40D) were constructed for long-term monitoring at the furthest extent of the perchlorate plume in the south, southwest, and northwest directions. Relevant boring logs, vertical profiling logs, and well construction diagrams are included in Attachment B of the Revised FSP OU3 SRI.

Historic data, provided in Attachment A of the Revised FSP OU3 SRI, show perchlorate concentrations in the shallow, intermediate, and deep aquifers at concentrations up to 90.5 parts per billion (ppb), 20.9 ppb, and 152 ppb, respectively. Isopleth maps and vertical profile cross sections (provided at the end of this worksheet) created from historic sampling results show the highest perchlorate concentrations located beneath the Site and at the center of the plume in the deep zone approximately half a mile southwest of the Site. The groundwater sampling results through 2011 showed that perchlorate migrated vertically from source areas at the Site to the deep zone and then migrated to the southwest in the downgradient direction. Nearby irrigation pumping wells may have influenced the local groundwater flow patterns in the vicinity of the plume.

The applicable standard for perchlorate in groundwater is the GWQS of 5 ppb. This endpoint will be protective of human receptors who may ingest groundwater on-Site and off-Site.

QAPP WORKSHEET #11: PROJECT/DATA QUALITY OBJECTIVES

The Data Quality Objective (DQO) process is a systematic planning tool that was designed to clarify the objectives of data collection and maximize efficiency during the data collection process. The DQO process is used to establish performance or acceptance criteria, which is the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of a study. There are seven steps to the DQO process as outlined in EPA/240/B-06-001, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006).

Step 1. State the Problem – This step defines the issues to be addressed in the RI/FS. Previous investigations at the Site have identified perchlorate in groundwater at levels above the GWQS. Nine years have elapsed since perchlorate was last investigated and it is necessary to characterize how the plume has changed to help USEPA select a remedy that will be protective of human health and meet the clean-up standards specified in CERCLA.

Step 2. Identify the Goal of the Study – This step identifies the question that the project will attempt to resolve and the actions which will be taken. As presented in Section 1.1 of the Revised FSP OU3 SRI, the goal is to investigate the current extent of the perchlorate plume, determine if the OU1 and OU2 remedies have influenced the perchlorate plume, assess the on-Site and off-Site geochemical characteristics, evaluate the USEPA concern that irrigation wells upgradient of the Site may be pulling groundwater from the Site upgradient.

Step 3. Identify Information Inputs – This step involves evaluation of existing data, identification of data gaps, and identification of new data needs. Shieldalloy has submitted several documents summarizing the previous investigations, findings of the usability assessment conducted for the data collected in these investigations, and the associated data in electronic format to the USEPA. The data include the results of previous investigations, historical uses and operations, regional geologic, hydrogeologic, and hydrologic information; surrounding land and water use; and other relevant information gathered. The quality of the data was evaluated and presented in the OU3 RIR (TRC, 2016).

New data are needed to characterize the current extent of the perchlorate plume and evaluate the current biogeochemical conditions in groundwater. The following data will be collected according to address these needs:

- Analytical parameters: perchlorate, total and dissolved iron, nitrate, sulfate, sulfide, orthophosphate, alkalinity, total organic carbon, total dissolved solids, and dissolved hydrocarbons (methane, ethane, ethene);
- Water quality parameters: pH, temperature, dissolved oxygen, oxidation reduction potential, turbidity, and specific conductivity;
- Compound Specific Isotope Analysis (CSIA);
- Gene-Trac; and
- Water level measurements.

Perchlorate undergoes natural attenuation by a variety of mechanisms, including biological reduction and physical processes including dilution and dispersion. During biological reduction, perchlorate serves as an electron acceptor, while organic carbon (either naturally present or in some cases co-released organic contaminants like oils) serves as an electron donor. The perchlorate is reduced via chlorate to chlorite, which then decomposes to chloride and oxygen. This reaction typically occurs under anaerobic conditions in the absence of oxygen. Geochemical conditions that are suitable for this reaction to occur typically include low DO concentrations, slightly negative ORP values, presence of some organic carbon, typically measured by total organic carbon (TOC) or dissolved organic carbon (DOC) analyses, and indications of conditions of nitrate reduction, sulfate reduction and/or methanogenesis. Elevated chloride and alkalinity can also in some cases provide evidence of natural attenuation of perchlorate. As such, these are all helpful indicator parameters in evaluating MNA. During biological reduction, the isotopic signature of perchlorate changes, and at some sites, CSIA analysis can provide evidence of perchlorate MNA. With respect to physical processes, perchlorate concentrations can decline as a result of dilution and dispersion. At some sites, these mechanisms are sufficient such that perchlorate plumes reach a stable size and no longer expand, allowing MNA to be a suitable remedy. While there are fewer analytical parameters that are indicative of these processes, perchlorate concentration declines can in many cases assess the contribution of these mechanisms to MNA. Additionally, Gene-Trac analysis may confirm the presence of perchlorate-reducing bacteria, which are known to be gram-negative, non-fermenting and completely oxidizing facultative anaerobes in the Proteobacteria phylum. Confirming the presence of the chlorite dismutase enzyme is also a useful indicator of natural perchlorate attenuation, but not necessary. Generally, geochemical data such as DO, pH, ORP, and nitrate can sufficiently demonstrate attenuation (ESTCP, 2008).

Step 4. Identify the Boundaries of the Study – This step is used to define the geographic and temporal boundaries. The boundary of the study area is the extent of the perchlorate plume resulting from Site activities. Sampling activities are expected to start in fall of 2020 and may be continued based upon the results of the initial investigation.

Step 5. Develop the Analytic Approach – The analytic approach summarizes how the information collected during the RI will guide the selection of an appropriate remedy. Samples will be collected and analyzed according to the sampling design provided in Worksheet #17 of this Quality Assurance Project Plan (QAPP). The below table describes how the data inputs will be used to guide remedy selection.

Perchlorate	Biogeochemical Parameters (1) and Water Quality Parameters (2)	Groundwater Level Measurements	Compound Specific Isotope Analysis
If the perchlorate concentrations at wells along the perimeter of the plume are less than 5 ppb then the plume will be considered delineated. If not, then additional wells may be installed to delineate the plume.	If the biogeochemical parameter data support natural attenuation, then natural attenuation will be considered as a remedy. If not, then natural attenuation will not be considered as a remedy.	If the groundwater level data are consistent, then the direction of groundwater flow will be determined. If not, then additional groundwater elevation data may be collected.	If the data show evidence of perchlorate with isotopic weights similar to natural sources found in fertilizer, then this information will be used to support the assumption that perchlorate is present in the background. If not, then perchlorate may not be present in the background.

1. Biogeochemical parameters - total and dissolved iron, nitrate, sulfate, sulfide, orthophosphate, alkalinity, total organic carbon, total dissolved solids, and dissolved hydrocarbons (methane, ethane, ethene)
2. Water quality parameters - pH, temperature, dissolved oxygen, oxidation reduction potential, turbidity, and specific conductivity

Step 6. Specify Performance or Acceptance Criteria – Uncertainty is present in all measurement data, and this step sets the standards at which the degree of uncertainty is acceptable. Project-specific standards details regarding the precision and accuracy control limits for each of the target analytes and matrices, as well as the overall project goals for completeness and representativeness are described in this QAPP.

Step 7. Develop the Plan for Obtaining Data – Worksheets 11 and 17 provide detailed information for collection of data sufficient to delineate perchlorate in groundwater. The Revised FSP OU3 SRI includes maps depicting sampling locations; a detailed description of the sampling analysis and testing to be performed, including sampling methods, analytical and testing methods, and frequency of sampling; and a description of how sampling data will be submitted to the USEPA.

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group or Method: Alkalinity by SM 2320B-2011 or EPA 310.1; WI11475
Concentration Level: Low

Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Accuracy/Bias	Laboratory statistical window (82-106%)	Laboratory Control Spike/Matrix Spike, Method Detection Limit Study	A
Accuracy/Laboratory Contamination	No analytes detected > LOQ or >1/10 the amount measured in any sample	Method Blank	A
Precision	Laboratory statistical RPD	Lab Duplicate	A
Precision	RPD <30%	Field Duplicate	S & A
Accuracy/Bias	No detected target compounds	Field Blank	S & A
Representativeness/Completeness	Samples collected and analyzed as described in the Revised FSP OU3 SRI and this QAPP Data Completeness > 90%	Data Completeness Check	S & A
Sensitivity	Detection limits ≤ to Project Action Limits (See Worksheet #15)	Detection limits	A

Acronym list
Revised FSP OU3 SRI – Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation
LOQ - limit of quantification
RPD - relative percent difference
QAPP – Quality Assurance Project Plan

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group or Method: Sulfide by SM 4500 S2D-2011 or EPA 376.2; WI11483
Concentration Level: Low

Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Accuracy/Bias/Precision	Laboratory statistical or method window and RPD, whichever is tighter (90-100%)	Laboratory Control Spike/Matrix Spike and their Duplicates, Method Detection Limit Study	A
Accuracy/Laboratory Contamination	No analytes detected > 1/2 LOQ or >1/10 the amount measured in any sample	Method Blank	A
Precision	Laboratory statistical RPD	Lab Duplicate	A
Precision	RPD <30%	Field Duplicate	S & A
Accuracy/Bias	No detected target compounds	Field Blank	S & A
Representativeness/Completeness	Samples collected and analyzed as described in the Revised FSP OU3 SRI and this QAPP Data Completeness > 90%	Data Completeness Check	S & A
Sensitivity	Detection limits ≤ to Project Action Limits (See Worksheet #15)	Detection limits	A

Acronym list
Revised FSP OU3 SRI – Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation
LOQ - limit of quantification
RPD - relative percent difference
QAPP – Quality Assurance Project Plan

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group or Method: Wet Chemistry – Inorganic Ions by IC (NO3, SO4) by EPA 300.0/9056; WI11626 Concentration Level: Low

Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Accuracy/Bias	Method limits (90-100%)	Laboratory Control Spike/Matrix Spike, Method Detection Limit Study	A
Accuracy/Laboratory Contamination	No analytes detected <MDL or >1/10 the amount measure in any sample.	Method Blanks	A
Precision	Laboratory statistical (90-110%)	Lab Duplicate	A
Precision	RPD <30%	Field Duplicate	S & A
Accuracy/Bias	No detected target compounds	Field Blank	S & A
Representativeness/Completeness	Samples collected and analyzed as described in the Revised FSP OU3 SRI and this QAPP Data Completeness > 90%	Data Completeness Check	S & A
Sensitivity	Detection limits ≤ to Project Action Limits (See Worksheet #15)	Detection limits	A

Acronym list
Revised FSP OU3 SRI – Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation
MDL - method detection limit
RPD - relative percent difference
QAPP – Quality Assurance Project Plan

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group or Method: Orthophosphate as Phosphorous by EPA 365.3; WI11511
Concentration Level: Low

Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Accuracy/Bias	Laboratory statistical windows (95-105%)	Laboratory Control Spike/Matrix Spike, Method Detection Limit Study	A
Accuracy/Laboratory Contamination	No analytes detected > LOQ or >1/10 the amount measured in any sample	Method Blank	A
Precision	Laboratory statistical RPD	Lab Duplicate	A
Precision	RPD <30%	Field Duplicate	S & A
Accuracy/Bias	No detected target compounds	Field Blank	S & A
Representativeness/Completeness	Samples collected and analyzed as described in the Revised FSP OU3 SRI and this QAPP Data Completeness > 90%	Data Completeness Check	S & A
Sensitivity	Detection limits ≤ to Project Action Limits (See Worksheet #15)	Detection limits	A

Acronym list
Revised FSP OU3 SRI – Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation
LOQ - limit of quantification
RPD - relative percent difference
QAPP – Quality Assurance Project Plan

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group or Method: Total Organic Carbon by SM 5310C/EPA 415.1; WI11637
Concentration Level: Low

Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Accuracy/Bias	Laboratory statistical limits and RPD (91-113%)	Laboratory Control Spike/Matrix Spike, Method Detection Limit Study	A
Accuracy/Laboratory Contamination	No analytes detected > MDL or >1/10 the amount measured in any sample	Method Blank	A
Precision	Laboratory statistical RPD	Lab Duplicate	A
Precision	RPD <30%	Field Duplicate	S & A
Accuracy/Bias	No detected target compounds	Field Blank	S & A
Representativeness/Completeness	Samples collected and analyzed as described in the Revised FSP OU3 SRI and this QAPP Data Completeness > 90%	Data Completeness Check	S & A
Sensitivity	Detection limits ≤ to Project Action Limits (See Worksheet #15)	Detection limits	A

Acronym list
Revised FSP OU3 SRI – Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation
MDL - method detection limit
RPD - relative percent difference
QAPP – Quality Assurance Project Plan

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group by Method/SOP: Dissolved Hydrocarbons (Methane, Ethane, Ethene) by RSK175 or SW-846 8015C or D/WI9796
Concentration Level: Low

Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Accuracy	Laboratory statistical windows (28-140%)	Surrogate Spike	A
Accuracy/Bias/Precision	Laboratory statistical limits (LCS: methane and ethane: 85-115%, ethene: 83-115%) (MS: methane: 73-125%, ethane: 74-131%, ethene: 72-133%)	Laboratory Control Spike/Matrix Spike and their Duplicates, Method Detection Limit Study	A
Accuracy/Laboratory Contamination	No analytes detected > RL or >1/10 the amount measured in any sample	Method Blank	A
Precision	RPD <30%	Field Duplicate	S & A
Accuracy/Bias	No detected target compounds	Field Blank	S & A
Accuracy/Transport Contamination	No detected target compounds	Trip Blank	A
Representativeness/Completeness	Samples collected and analyzed as described in the Revised FSP OU3 SRI and this QAPP Data Completeness > 90%	Data Completeness Check	S & A
Sensitivity	Detection limits ≤ to Project Action Limits (See Worksheet #15)	Detection limits	A

Acronym list
Revised FSP OU3 SRI – Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation
RL – reporting limit
RPD - relative percent difference
QAPP – Quality Assurance Project Plan

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group by Method/SOP: Wet Chemistry – Total Dissolved Solids (TDS) by SM 2540 C-2011; WI11597
Concentration Level: Low

Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Accuracy	Laboratory statistical windows (72-127%)	Surrogate Spike	A
Accuracy/Bias/Precision	Laboratory statistical limits (72-127%)	Laboratory Control Spike/Matrix Spike and their Duplicates, Method Detection Limit Study	A
Accuracy/Laboratory Contamination	No analytes detected > RL or >1/10 the amount measured in any sample	Method Blank	A
Precision	RPD <30%	Field Duplicate	S & A
Accuracy/Bias	No detected target compounds	Field Blank	S & A
Accuracy/Transport Contamination	No detected target compounds	Trip Blank	S & A
Representativeness/Completeness	Samples collected and analyzed as described in the Revised FSP OU3 SRI and this QAPP Data Completeness > 90%	Data Completeness Check	S & A
Sensitivity	Detection limits ≤ to Project Action Limits (See Worksheet #15)	Detection limits	A

Acronym list
Revised FSP OU3 SRI – Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation
RL – reporting limit
RPD - relative percent difference
QAPP – Quality Assurance Project Plan

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group by Method/SOP: Metals (Total and Dissolved Iron)- ICP/MS by EPA 200.8 WI11933
Concentration Level: Low

Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Accuracy/Bias/Precision	Laboratory Statistical Limits (85-115%); RPD ≤20%	Laboratory Control Spike/Laboratory Control Spike Duplicate, Method Detection Limit Study	A
Accuracy/Bias/Precision	Laboratory Statistical Limits (70-130%); RPD ≤20%	Matrix Spike/Matrix Spike Duplicate	A
Accuracy/Laboratory Contamination	No analytes detected > 1/2 LOQ or 2.2x MDL, whichever is greater, or >1/10 the amount measured in any sample.	Method Blank	A
Precision	RPD ≤20%	Lab Duplicate	A
Precision	RPD <30%	Field Duplicate	S & A
Accuracy/Bias	No detected target compounds	Field Blank	S & A
Representativeness/Completeness	Samples collected and analyzed as described in the Revised FSP OU3 SRI and this QAPP Data Completeness > 90%	Data Completeness Check	S & A
Sensitivity	Detection limits ≤ to Project Action Limits (See Worksheet #15)	Detection limits	A

Acronym list
Revised FSP OU3 SRI – Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation
LOQ - limit of quantification
MDL - method detection limit
RPD - relative percent difference
QAPP – Quality Assurance Project Plan

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group by Method/SOP: Perchlorate by SW-846 6850 WI9989
Concentration Level: Low

Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Accuracy/Bias/Precision	Laboratory statistical limits (80-120%)	Laboratory Control Spike/Matrix Spike and their Duplicates, Method Detection Limit Study	A
Accuracy/Laboratory Contamination	No analytes detected > RL or >1/10 the amount measured in any sample	Method Blank	A
Precision	RPD <30%	Field Duplicate	S & A
Accuracy/Bias	No detected target compounds	Field Blank	S & A
Representativeness/Completeness	Samples collected and analyzed as described in the Revised FSP OU3 SRI and this QAPP Data Completeness > 90%	Data Completeness Check	S & A
Sensitivity	Detection limits ≤ to Project Action Limits (See Worksheet #15)	Detection limits	A

Acronym list
Revised FSP OU3 SRI – Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation
RL – reporting limit
RPD - relative percent difference
QAPP – Quality Assurance Project Plan

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA (CONTINUED)

Laboratory: Environmental Isotope Geochemistry Laboratory: University of Delaware, Newark, DE
Matrix: Groundwater
Analytical Group by Method/SOP: CSIA Perchlorate analysis
Concentration Level: Low

Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Accuracy/Bias/Precision	Laboratory statistical limits	Normalization using $KClO_4$ isotopic reference materials	A
Accuracy/Bias/Precision	Laboratory statistical limits	Continuing Calibration Verification	A
Accuracy/ Bias	Laboratory statistical limits	Comparison of $KClO_4$ isotopic reference materials (USGS37, USGS38, USGS38) to certified specifications	A
Precision	RPD <30%	Field Duplicate	S
Accuracy/Bias	N/A	The sampling protocol is designed to concentrate the $KClO_4$ sample mass to overwhelm any noise associated with field contamination[1].	S & A
Representativeness/Completeness	Samples collected and analyzed as described in the Revised FSP OU3 SRI and this QAPP Data Completeness > 90%	Data Completeness Check	S & A
Sensitivity	N/A	Sample result is reported as a ratio rather than an absolute value therefore there is no detection limit.	A

1. Field blanks are only recommended for CSIA analysis if the groundwater concentrations are in the mg/L range. Otherwise, the unique method of sample collection onto columns rather than collection of purge water in sample bottles is considered sufficient to avoid field blank interference. We do not anticipate any results in the mg/L range, and therefore no field blanks are planned.

Acronym list

Revised FSP OU3 SRI – Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation
RPD - relative percent difference
QAPP – Quality Assurance Project Plan

QAPP WORKSHEET #13: SECONDARY DATA USES AND LIMITATIONS

Data type	Source	Data uses relative to current project	Factors affecting the reliability of data and limitations on data use
Past site uses	TRC Environmental Corporation (TRC), 1992. Remedial Investigation Technical Report, 1992. TRC, 2005. Phase I Environmental Site Assessment and Environmental Compliance Summary, August 2005.	How and where perchlorate was used on-Site.	No known limitations.
Regional perchlorate groundwater concentrations	To be based data from studies of perchlorate in groundwater. For example, studies of the impacts of perchlorate use in agricultural areas, and studies of perchlorate impacts at other industrial sites.	Comparison of regional agriculture-related perchlorate groundwater concentrations to perchlorate groundwater concentrations in the perchlorate plume related to the Site.	No known limitations.

Past site uses data provides information on how and where perchlorate was historically used on-Site. These data were considered when determining where Phase 1 borings will be advanced.

QAPP WORKSHEET #14 & 16: SUMMARY OF PROJECT TASKS AND SCHEDULE

Sampling Tasks:

Perchlorate was last investigated in 2011, at which time the groundwater concentrations exceeded the Groundwater Quality Standard (GWQS) of 5 ppb (USEPA reference). The overall objective of this investigation is to determine the extent of the perchlorate plume:

- Collect groundwater samples for perchlorate analysis to delineate the current extent of the perchlorate plume;
- Collect groundwater samples for geochemical analysis to characterize the geochemical properties of the subsurface;
- Collect water level measurements on site to assess groundwater flow;
- Collect field parameters, specifically temperature, pH, specific conductivity, dissolved oxygen (DO), turbidity, and oxidation reduction potential (ORP),
- Collect groundwater samples for Compound-Specific Isotope Analysis (CSIA) analysis to evaluate the presence and source of background perchlorate; and
- Collect groundwater samples for Gene-trac analysis to assess the potential for biological degradation of perchlorate in the subsurface.

See Worksheet 17 for an overview of the conceptual basis and rationale for characterization for each task, and Worksheet 18 for a discussion of the investigative methods.

Analytical Tasks:

- Groundwater elevation measurements
- Field geochemistry: pH, DO, ORP, specific conductance, turbidity and temperature by flow through water quality meter
- Groundwater analytical tasks to be analyzed by Eurofins Lancaster Laboratories Environmental will include:
    - Perchlorate via SW-846 6850
    - Metals (Total & Dissolved Iron) via USEPA Method 200.8
    - Dissolved Hydrocarbons (Methane, Ethane, Ethene) via RSK175 or SW-846 8015C
    - Total Dissolved Solids by SM 2540 C-2011
    - Total Organic Carbon via SM 5310C/ EPA 415.1
    - Orthophosphate as Phosphorous via EPA 365.3
    - Inorganic Ions by IC (NO_3 and SO_4) by EPA 300.0/9056
    - Sulfide by SM4500 S2D/ EPA 376.2
    - Alkalinity by SM 2320B-2011 or EPA 310.1

- Groundwater analytical tasks to be analyzed by Environmental Isotope Geochemistry Laboratory: University of Delaware will include Compound Specific Isotope Analysis
- Groundwater analytical tasks to be analyzed by SiREM will include Gene-Trac®

QAPP WORKSHEET #14 & 16: SUMMARY OF PROJECT TASKS AND SCHEDULE (CONTINUED)

Quality Control (QC) Tasks:

For all samples collected for analysis by Eurofins Lancaster Laboratories Environmental, equipment blanks and field blanks will be collected to determine if contamination of samples has occurred in the field and, if possible, to quantify the extent of the impact on field samples. Trip blanks will be submitted along with all dissolved hydrocarbon samples at a frequency of one per cooler containing dissolved hydrocarbon samples. Field duplicate samples and matrix spike/matrix spike duplicate (MS/MSD) samples will also be collected (see Worksheet #20 for QC Sample frequency). The field duplicate QC samples will be submitted as blind duplicates with only the date collected recorded on the chain of custody (COC). The samples will be identified as duplicate, trip blank, equipment blank, and MS/MSD samples in the final report.

For all samples collected for analysis by University of Delaware, equipment, trip, and field blanks are not feasible given the method of sampling and would not provide a meaningful assessment of contamination since the sample result is provided as an isotopic ratio, rather than an absolute value. Additionally, the analysis method does not allow for MS/MSD analysis, therefore they will not be collected. The sample collection method is designed to collect a sufficient mass of perchlorate within the sample column by purging a large volume of sample water through the column so as to reduce the potential for interference from contamination. Field duplicate samples will be collected and submitted to the lab as blind duplicates with only the collection date recorded on the COC.

For all samples collected for analysis by SiREM no QC samples will be collected. The results from the Gene-Trac® analyses will not be used for any quantitative decisions on site; however, the standard control sample QC results will be included with the reported results. The data will be used to inform decisions about the feasibility of various perchlorate remedies on site based on the presence or absence of certain biological populations which can degrade perchlorate.

A summary of the field QC samples to be collected during the sampling program are presented as follows:

- Trip blanks (for dissolved hydrocarbons only);
- Equipment blanks consisting of laboratory-supplied analyte-free water poured over or pumped through groundwater sampling equipment; Field blanks consisting of laboratory-supplied analyte free water poured into sample containers in the field for all analyses except for CSIA and Gene-Trac®;
- Field duplicate samples for all groundwater samples except for Gene-Trac®; and
- MS/MSD samples for all groundwater samples except for CSIA and Gene-Trac®.

QAPP WORKSHEET #14 & 16: SUMMARY OF PROJECT TASKS AND SCHEDULE (CONTINUED)

Data Management

Data are generated from three primary pathways: i) data derived from field activities; ii) laboratory analytical data; and iii) validated data. Data from all three pathways are entered into the project database in an electronic format in accordance with the project protocols.

Data generated during field activities are recorded using a field log book and field forms. Forms will be reviewed for completeness and accuracy by the Field Manager. Pertinent data from the field forms are entered into the project database. Hard copy field records are stored in a secure project file.

Data generated during laboratory analysis are recorded in hard copies, electronic reports in pdf format, and in electronic data deliverables (EDDs) after the samples have been analyzed. These data are then submitted for data validation. Data validation is performed in accordance with Worksheets #33, #34, #35, #36, and #37. The data validation team works with the project database manager to facilitate the uploading of the validated data into the project database in accordance with the project protocols.

Hard copies of field forms, data, and chain of custody (COC) forms are filed in a secure storage area. Laboratory data packages and reports are archived at the Geosyntec project office for a minimum of 15 years. Laboratories that generated the data archive data for 5 years unless instructed not to per project specifications. Field data are recorded manually in the project field book and uploaded to the project drive on a daily basis (i.e., scanned copies of hand-written notes).

Documentation and Records

In association with sample collection, field personnel are required to document all pertinent data, including date, time, location (coordinates), field personnel, weather conditions, instrument identification, and any other factors that may affect data quality. COC procedures in Worksheet #27 are followed for all samples. Hardcopy data (e.g., field note books; photos; hard copies of COC forms; and other items) are housed at Geosyntec offices and kept in the project files.

Assessment/Audit Tasks

Review of standard operating procedures (SOPs) relating to field, data validation, and project activities is required prior to project start. Audit records of the laboratories are maintained by the laboratory and available upon request.

QAPP WORKSHEET #14 & 16: SUMMARY OF PROJECT TASKS AND SCHEDULE (CONTINUED)

Task or Event	Responsible Party	Planned Start Date	Planned Completion Date	Deliverable(s)	Deliverable Due Date
Submit Revised Field Sampling Plan (including QAPP and HASP) for final USEPA approval	Geosyntec Consultants, Inc.	August 13, 2020	September 30, 2020	USEPA-approved Revised Field Sampling Plan (including QAPP and HASP)	September 30, 2020
Mobilize for Phase 1	Geosyntec Consultants, Inc.	October 1, 2020	October 16, 2020	Field notes	October 16, 2020
Implement Phase 1 field work	Geosyntec Consultants and Cascade Drilling, L.P.	October 19, 2020	November 6, 2020	Field notes	November 6, 2020
Complete laboratory analyses	Eurofins Lancaster Laboratories Environmental, LLC	December 4, 2020	December 18, 2020	Report of analyses/Data package	January 4, 2020
Data validation	Geosyntec Consultants, Inc.	December 7, 2020	December 18, 2020	Validation Summary Report	December 18, 2020
Prepare Phase 1 Results Memorandum (including Useability Assessment)	Geosyntec Consultants, Inc.	December 21, 2020	January 21, 2021	Draft Phase I Results Memorandum (and Useability Assessment)	January 22, 2021
USEPA Review of Phase 1 Results Memorandum	USEPA	January 22, 2021	March 5, 2021	Comments on Phase 1 Results Memorandum	March 5, 2021

Respond to USEPA Comments	Geosyntec Consultants, Inc.	March 5, 2021	April 5, 2021	Response to Comments on Phase I Results Memorandum	April 5, 2021

QAPP WORKSHEET #14 & 16: SUMMARY OF PROJECT TASKS AND SCHEDULE (CONTINUED)

Receive final USEPA approval for Phase 1 Memorandum	Geosyntec Consultants, Inc.	April 5, 2021	April 12, 2021	USEPA-approved Phase I Memorandum	April 12, 2021
Implement Phase 2 (if needed), including field work, laboratory analyses, data validation, and Results Memorandum (see note)	Geosyntec Consultants, Inc.	April 26, 2021	July 30, 2021	Field notes, Report of analyses/Data package, Validation Summary Report, Phase 2 Results Memorandum	July 30, 2021

Note – The scope of Phase 2, if needed, will be developed based on the results of Phase 1. The schedule for Phase 2 is contingent on the scope and is tentative.

QAPP WORKSHEET #15: PROJECT ACTION LIMITS AND LABORATORY-SPECIFIC DETECTION/QUANTITATION LIMITS

Laboratory: Eurofins Lancaster Laboratory Environmental, Lancaster, PA
Matrix: Groundwater

Analyte	CAS Number	Project Action Limit (mg/L)	Project Quantitation Limit Goal[1] (mg/L)	Method Specific		Laboratory Specific	
				Method Detection Limit (mg/L)	Quantitation Limit (mg/L)	Method Detection Limit (mg/L)	Quantitation (Reporting) Limit (mg/L)
Perchlorate	PHCDC10C28	0.005	0.001	0.0002	0.001	0.0002	0.001
Nitrate	14797-55-8	--	0.5	0.25	0.5	0.25	0.5
Sulfate	14808-79-8	--	4.5	1.5	4.5	1.5	4.5
Orthophosphate as Phosphorous	7723-14-0	--	0.01	0.003	0.01	0.003	0.01
Total Alkalinity	--	--	5	1.7	5	1.7	5
TOC	--	--	1	0.5	1	0.5	1
TDS	--	--	20	20	60	20	60
Sulfide	18496-25-8	--	0.1	0.1	0.2	0.1	0.3
Iron (Total and Dissolved)	7439-89-6	--	0.0228	0.0228	0.1	0.0228	0.1
Methane	74-28-8	--	0.003	0.003	0.005	0.003	0.005
Ethane	74-84-0	--	0.001	0.001	0.005	0.001	0.005
Ethene	74-85-1	--	0.001	0.001	0.005	0.001	0.005

1. For each compound, the project quantitation limit goal is equal to the laboratory's quantitation limit or Reporting Limit (RL).
- = not applicable

Acronym list
mg/L – milligrams per Liter
TDS-Total Dissolved Solids
TOC- Total Organic Carbon

QAPP WORKSHEET #15: PROJECT ACTION LIMITS AND LABORATORY-SPECIFIC DETECTION/QUANTITATION LIMITS (CONTINUED)

Laboratory: Environmental Isotope Geochemistry Laboratory: University of Delaware, Newark, DE
Matrix: Groundwater

Analyte	CAS Number	Project Action Limit	Project Quantitation Limit Goal	Method Specific		Laboratory Specific	
				Method Detection Limit	Quantitation Limit	Method Detection Limit	Quantitation (Reporting) Limit
Perchlorate	PHCDC10C28	NA[1]	NA	NA	NA	NA	NA

1. Compound Specific Isotopic Analysis sample results are reported as ratios rather than absolute values therefore there is no detection limit or project action limit. Data analysis will be dependent upon the sample results' variation from known endmember perchlorate ratios. A mixing model will be used to determine the influence of various endmembers on the samples collected and statistical significance will be used as an indicator of data usability.

QAPP WORKSHEET #17: SAMPLING DESIGN AND RATIONALE

The following section summarizes the sampling design and rationale which will serve to characterize the perchlorate plume. Perchlorate concentrations will be delineated to the 5 ppb GWQS. All investigative methods shall be consistent with generally accepted professional methods, as described in the USEPA Region II Ground Water Sampling Procedure (USEPA, 1998). The groundwater investigation will be conducted pursuant to the requirements in N.J.A.C. 7:26E-4.1 and according to the quality assurance and quality control requirements pursuant to N.J.A.C. 7:26E-2.

In 2011 and prior, groundwater samples were collected from a monitoring well network at the Site that was largely developed to monitor chlorinated VOCs (OU1). Much of the perchlorate delineation was completed using borings and groundwater screening samples which allowed the sampling plan to be adjusted to delineate the plume configuration at that time. The results of the previous sampling conducted using vertical profile borings (VPBs) are shown in the isopleth concentration figures (provided at the end of Worksheet #10) from the Site Characterization Summary Report (SCSR; TRC, June 2011). The figures show groundwater results at three depth zones: shallow (generally 15 to 50 feet bgs); intermediate (generally 55 to 85 feet bgs); and deep (generally 85 to 135 feet bgs). In the shallow zone, perchlorate impacts were limited to the Site and the area immediately downgradient of the Site. Perchlorate was present in the intermediate zone downgradient of the Site, but at relatively low concentrations. Perchlorate was present in the deep zone both near and downgradient of the Site, at higher concentrations than in the intermediate zone. The results indicate some migration of perchlorate from the on-Site source areas in the deep zone. This was likely due in part to the natural flow in groundwater but may also have been influenced by the effects of pumping wells (including wells used for remediation of OU1 and irrigation wells) which would have drawn the perchlorate deeper and further from the Site. The OU1 remediation wells were turned off on or around April 30, 2013.

Given the age of the data and because the well network may not be appropriate to evaluate the current distribution of perchlorate, an approach consisting of two phases has been developed.

- Phase 1 – advancing soil borings and collecting groundwater samples from the borings to estimate the current distribution of perchlorate in groundwater at and downgradient of the Site; and

- Phase 2 – installation of permanent monitoring to wells to confirm the perchlorate distribution, allow collection of samples to evaluate natural attenuation processes for perchlorate, and to allow long-term monitoring of perchlorate.

Phase 1

The overall approach to Phase 1 will be to (1) return to certain of the previous sampling locations to determine whether perchlorate concentrations have remained similar since 2011; and (2) to estimate the downgradient extent of perchlorate. Ten boring locations are proposed, as summarized in the following table and shown on Figure 3 of the Revised FSP OU3 SRI. The majority of the borings are on the flow path from the Site to the southwest (based on historical water level data).

Boring Location	Depth	Purpose
GWS1	80 feet	Upgradient, to establish perchlorate concentrations in groundwater entering the Site.
GWS2	120 feet	Within former area of highest concentrations on Site.
GWS3	130 feet	At Farm Parcel, downgradient of Site, where pumping wells were operated for OU1.
GWS4	120 feet	At former boring location VP-8, where highest concentrations of perchlorate were detected in the off-Site deep zone.
GWS5	140 feet	At former boring location VP-5, to establish southern (side gradient) boundary of perchlorate.
GWS6	120 feet	At former boring location VP-13A, to establish northern (side gradient) boundary of perchlorate.
GWS7	120 feet	At former boring location VP-2, where elevated levels of perchlorate were observed in intermediate and deep zones.
GWS8	120 feet	Near former boring location VP-10, to delineate downgradient edge of perchlorate.
GWS9	120 feet	On West Forest Grove Road, west of former boring location VP-10, to delineate downgradient edge of perchlorate.
GWS10	110 feet	Near former boring location VP-15A, to delineate downgradient edge of perchlorate.

Phase 2

Phase 2 will be implemented if the results of Phase 1 indicate that perchlorate is present at concentrations above its GWQS and remediation is required. Phase 2 will consist of the installation and sampling of well nests. Each well nest will contain three wells, one each in the shallow, intermediate, and deep zones.

The general approach to the Phase 2 well nest locations will be:

- Provide upgradient monitoring at the Site to understand perchlorate levels in groundwater flowing on to the Site, and to help define groundwater flow directions;

- Install well nests in areas of elevated perchlorate concentrations (which may be the same as those defined in the previous sampling, or may be different);

- Provide monitoring to define the extent perpendicular to the groundwater flow direction (likely north and south) and downgradient edge (likely southwest) of the perchlorate.

All samples will be analyzed for perchlorate using method SW-846 6850. Samples at selected new wells will be analyzed for the following parameters to evaluate potential natural attenuation processes for perchlorate:

- Total and dissolved iron;
- Nitrate;
- Sulfate;
- Sulfide;
- Orthophosphate;
- Alkalinity;
- Total organic carbon;
- Total dissolved solids; and
- Dissolved hydrocarbons (methane, ethane, and ethene).

In addition, samples may be collected for analysis compound-specific isotope analysis (CSIA) and Gene-Trac testing. The locations for these samples will be selected in conjunction with USEPA. If collected, CSIA samples will preferentially be collected at locations on the perimeter of the perchlorate plume and with perchlorate concentrations of at least 5 micrograms per liter (µg/L). Higher concentrations of perchlorate are preferred because the sampling procedure for CSIA, discussed in detail in Appendix C of the Revised FSP OU3 SRI, requires pumping a large volume of water (i.e., 2,000 liters for a well with a perchlorate concentration of 5 µg/L) through an ion exchange column at a rate of no greater than 2 liters per minute to adsorb all perchlorate to the resin within the ion exchange column. Samples will be analyzed by CSIA to determine the isotopic composition of the perchlorate, since synthetic and naturally formed perchlorate have different isotopic compositions/signatures (Sturchio et al., 2011). This may provide evidence of the source of the perchlorate, as the synthetic perchlorate likely used at the Site should have a different isotopic signature than natural perchlorate in fertilizers used at farms near the Site (ITRC, 2005; USEPA, 2014).

Gene-Trac testing may also be used to quantify key microorganisms and to determine microbial composition for the assessment of bioremediation potential. If Gene-Trac testing is used, samples will be collected at locations with the highest perchlorate concentrations during the initial sampling round. The Gene-Trac samples will be processed, frozen, and held for analysis until a remedy is selected. They will be analyzed if the selected remedy includes a bioremediation component that requires bacterial analysis.

QAPP WORKSHEET #18: SAMPLING LOCATIONS AND METHODS

See Figure 3 and Section 3 of the Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation.

QAPP WORKSHEET #19: ANALYTICAL SOP REQUIREMENTS TABLE

Laboratory: Eurofins Lancaster Laboratory Environmental, Lancaster, PA
Matrix: Groundwater

Matrix	Analytical Group	Analytical and Preparation Method	Laboratory SOP	Sample Volume/Mass per Analysis	Containers (number, size, and type)	Preservation Requirements (Chemical, temperature, light protected)	Max Holding Time
Groundwater	Alkalinity	SM 2320B-2011 or EPA 310.1	WI11475	250 mL	250 mL plastic or glass bottle	Cool, ≤6°C	14 days
	Sulfide (colorimetric)	SM4500 S2D/ EPA 376.2	WI11483	250 mL	250 mL glass bottle	Cool, ≤6°C, no headspace, NaOH, ZnAc	7 days
	Anions: Nitrate and Sulfate	EPA 300.0 or SW-846 9056	WI11626	50 mL	50 mL plastic vial	Cool, ≤6°C	28 days
	Orthophosphate as Phosphorous	EPA 365.3	WI11511	250 mL	250 mL plastic or glass bottle	Cool, ≤6°C, Filter 0.45 µ on-site	48 hours
	Total Organic Carbon	SM 5310C/EPA 415.1	WI11637	40 mL	2 x 40 mL amber glass vial	Cool, ≤6°C, H3PO4 to pH <2	28 days
	Total Dissolved Solids	SM 2540 C-2011	WI11597	250 mL	500 mL plastic or glass bottle	Cool, ≤6°C	7 days
	Methane, Ethane, Ethene	RSK175/ or SW-846 8015C or D	WI9015178	40 mL	2 x 40 mL glass vials, no headspace	HCL to pH<2; Cool, ≤6°C, no headspace	7 days
	Metals (Total and Dissolved Iron)	EPA 200.8	WI11933	250 mL	250 mL plastic	Field filter 0.45 µ (dissolved); HNO3 to pH <2 (total and dissolved)	6 months
	Perchlorate	SW-846 6850	WI9989	40 mL	40 mL glass vial	Cool, ≤6°C	28 days

Acronym list
mL – milliliter
SOP – Standard Operating Procedure

QAPP WORKSHEET #19: ANALYTICAL SOP REQUIREMENTS TABLE (CONTINUED)

Laboratory: Environmental Isotope Geochemistry Laboratory: University of Delaware, Newark, DE
Matrix: Groundwater

Matrix	Analytical Group	Analytical and Preparation Method	SOP	Sample Volume/Mass per Analysis (mg)[2]	Containers (number, size, and type)	Preservation Requirements (Chemical, temperature, light protected	Max Holding Time
Groundwater	CSIA	CSIA	ESTCP: Guidance Manual for Forensic Analysis of Perchlorate in Groundwater using Chlorine and Oxygen Isotopic Analyses[1]	10	1 ion exchange column (1.25" by 3")	Filtered, none, 2-4° C	NA

1. This guidance document is provided in the Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation, Appendix C. There is no SOP for CSIA sampling, protocols will be based on the provided guidance document with any updates required.
2. Volume of sample water purged will vary by well, sample mass is listed as mg of total perchlorate. The sample mass will be collected by pumping the required volume of water (i.e., 2000 L for a well with a perchlorate concentration of 5 µg/L) through the ion exchange column at a rate of no greater than 2L/min to adsorb all perchlorate to the resin within the ion exchange column.

Acronym list
CSIA – Compound-Specific Isotope Analysis
ESTCP - Environmental Security Technology Certification Program
SOP – Standard Operating Procedure
mg - milligram

QAPP WORKSHEET #20: FIELD QC SUMMARY

Laboratory: Eurofins Lancaster Laboratory Environmental, Lancaster, PA
Matrix: Groundwater

Matrix	Analytical Group	Conc. Level	Analytical and Preparation SOP Reference	No. of Field Duplicate Pairs	No. of MS/MSD	No. of Field Blanks	No. of Equipment Blanks	No. of Trip Blanks
Groundwater	Alkalinity	Low	SM 2320B-2011 or EPA 310.1	1 per 20 samples	1 per 20 samples	1 per day or 1 per 20 samples whichever is greater	1 per day or 1 per 20 samples whichever is greater	N/A
	Sulfide (colorimetric)	Low	SM4500 S2D/ EPA 376.2	1 per 20 samples	1 per 20 samples	1 per day or 1 per 20 samples whichever is greater	1 per day or 1 per 20 samples whichever is greater	N/A
	Anions: Nitrate and Sulfate	Low	EPA 300.0 or SW-846 9056	1 per 20 samples	1 per 20 samples	1 per day or 1 per 20 samples whichever is greater	1 per day or 1 per 20 samples whichever is greater	N/A
	Orthophosphate as Phosphorous	Low	EPA 365.3	1 per 20 samples	1 per 20 samples	1 per day or 1 per 20 samples whichever is greater	1 per day or 1 per 20 samples whichever is greater	N/A
	Total Organic Carbon	Low	SM 5310C/EPA 415.1	1 per 20 samples	1 per 20 samples	1 per day or 1 per 20 samples whichever is greater	1 per day or 1 per 20 samples whichever is greater	N/A
	Total Dissolved Solids	Low	SM 2540 C-2011	1 per 20 samples	1 per 20 samples	1 per day or 1 per 20 samples whichever is greater	1 per day or 1 per 20 samples whichever is greater	N/A

Acronym list
MS/MSD - Matrix Spike/Matrix Spike Duplicate

QAPP WORKSHEET #20: FIELD QC SUMMARY (CONTINUED)

Laboratory: Eurofins Lancaster Laboratory Environmental, Lancaster, PA
Matrix: Groundwater

Matrix	Analytical Group	Conc. Level	Analytical and Preparation SOP Reference	No. of Field Duplicate Pairs	No. of MS/MSD	No. of Field Blanks	No. of Equipment Blanks	No. of Trip Blanks
Groundwater	Dissolved Hydrocarbons (Methane, Ethane, and Ethene)	Low	RSK175/ or SW-846 8015C or D	1 per 20 samples	1 per 20 samples	1 per day or 1 per 20 samples whichever is greater	1 per day or 1 per 20 samples whichever is greater	1 per cooler
	Metals (Total and Dissolved Iron)	Low	EPA 200.8	1 per 20 samples	1 per 20 samples	1 per day or 1 per 20 samples whichever is greater	1 per day or 1 per 20 samples whichever is greater	N/A
	Perchlorate	Low	SW-846 6850	1 per 20 samples	1 per 20 samples	1 per day or 1 per 20 samples whichever is greater	1 per day or 1 per 20 samples whichever is greater	N/A

Acronym list
MS/MSD - Matrix Spike/Matrix Spike Duplicate

QAPP WORKSHEET #20: FIELD QC SUMMARY (CONTINUED)

Laboratory: Environmental Isotope Geochemistry Laboratory: University of Delaware, Newark, DE
Matrix: Groundwater

Matrix	Analytical Group	Conc. Level	Analytical and Preparation SOP Reference	No. of Field Duplicate Pairs	No. of MS/MSD	No. of Field Blanks	No. of Equipment Blanks	No. of Trip Blanks
Groundwater	CSIA	Low	ESTCP: Guidance Manual for Forensic Analysis of Perchlorate in Groundwater using Chlorine and Oxygen Isotopic Analyses[1]	1 per 10 samples	N/A	N/A	N/A	N/A

1. This guidance document is provided in the Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation, Appendix C. There is no SOP for CSIA sampling, field protocols will be based on the Environmental Isotope Geochemistry Laboratory Instructions for Perchlorate Collection Field Columns (Appendix C of the Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation) with any updates required.

Acronym list

CSIA – Compound-Specific Isotope Analysis
ESTCP - Environmental Security Technology Certification Program
MS/MSD - Matrix Spike/Matrix Spike Duplicate
SOP – Standard Operating Procedure

QAPP WORKSHEET #21: FIELD SOPS

SOP Number	Title, Revision Date and / or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
SOP 100	Water Level Measurement Procedures, February 2007	Geosyntec Consultants	Not applicable	N	-
SOP 101	Field Documentation, Sample Designation, Custody and Handling Procedures, November 2014	Geosyntec Consultants	Not applicable	N	-
SOP 104	Management and Disposal of Investigation Derived Waste, November 2014	Geosyntec Consultants	Applies to purge water, section 2	N	-
SOP 106	Water and NAPL Level Measurement Procedures, November 2014	Geosyntec Consultants	Not applicable	N	-
SOP 107	Soil Description: Visual – Manual Procedure of the Unified Classification System, November 2014	Geosyntec Consultants	Not applicable	N	-
SOP 108	Collection of Groundwater Samples, November 2014	Geosyntec Consultants	Samples will be collected by bailer (Phase 1) and pump (Phase 2)	N	-
SOP (Cascade)	Groundwater Sampling with Push-Ahead™ Tool	Cascade Drilling and Technical Services	Not applicable	N	-
SOG NJ1	Dissolved Oxygen (DO) Calibration, Revision 1, April 2018	Geosyntec Consultants	Not applicable	N	-
SOG NJ2	Specific Conductance Calibration, Revision 1, April 2018	Geosyntec Consultants	Not applicable	N	-

SOG NJ3	**Temperature Calibration, Revision 1, April 2018**	**Geosyntec Consultants**	**Not applicable**	**N**	**-**
SOG NJ4	**Turbidity Calibration, revision 1, April 2018**	**Geosyntec Consultants**	**Not applicable**	**N**	**-**
SOG NJ5	**pH Calibration, revision 1, April 2018**	**Geosyntec Consultants**	**Not applicable**	**N**	**-**

1. **The above SOPs are provided in Appendix A of the Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation.**

Acronym list

SOP – Standard Operating Procedure
SOG – Standard Operating Guideline

QAPP WORKSHEET #22: FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION

YSI 650MDS with YSI 600 XL/XLM, 6920, or 6820 sonde; YSI 556; or equivalent

Parameters: YSIs will be utilized during groundwater sampling and monitoring to analyze for dissolved oxygen, specific conductivity, temperature, pH, and oxidation/reduction potential.

Calibration: Parameter-specific calibration solutions will be used to calibrate individual sensors. Calibration parameters will include:

- Conductivity: Single-point calibration
- Turbidity: Three-point calibration
- Dissolved oxygen: Single-point calibration (100% saturation in air)
- Temperature: Factory calibrated (temperatures of all calibration standards should be recorded during calibration)
- pH: Three-point calibration (including 7.0)
- Oxidation/Reduction potential (ORP): Single-point calibration

Calibration will be performed in accordance with instrument instruction manuals. Ensure that calibration solutions are not past the expiration date prior to calibration. Expired solutions will not be used to calibrate instruments. Water depth does not require calibration.

Maintenance: see below SOPs.

Inspection: The YSI Sonde should be inspected throughout the day during real-time use to ensure proper function. Sensors should be inspected for cleanliness and integrity. Cables should be inspected for cuts and abrasions and display units should be inspected for proper function. All inspection activities should be documented, as appropriate.

Frequency: Calibration should be done at the beginning of the day, and whenever readings are outside of acceptable limits (see below). Inspection should be done during testing, calibration or whenever damage to the YSI may have occurred. A final calibration check will be recorded at the end of the day.

Acceptance:

Parameter	Units	Criteria
pH	pH units	± 0.3 pH units
ORP	mV	± 10 mV
Temperature	°C	NA
Conductivity	µS/cm	± 5% of standard or ± 10 µS/cm (whichever is greater)
Dissolved Oxygen	mg/L	± 0.5 mg/L of sat. value

Acronym list

SOP – Standard Operating Procedure

QAPP WORKSHEET #22: FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION (CONTINUED)

YSI 650MDS with YSI 600 XL/XLM, 6920, or 6820 sonde; YSI 556; or equivalent (continued)
Corrective Action: The initial corrective action for parameters falling outside of the acceptable accuracy range will be inspection of deficient sensors for dirt, deposits, or damage followed by recalibration of affected sensors. YSI recalibration should be conducted whenever readings fall outside of acceptance criteria. Some minor repairs or replacements, such as replacement of dissolved oxygen sensor membranes, may be done by field team members on site, while other repairs will require a professional repair service. Replacement batteries should be kept on hand for prompt replacement if battery levels are observed to be low or error codes indicate low batteries. Separate batteries are required for the YSI Sonde and digital display, and both should be kept on hand. If midday or end-of-day checks identify results outside acceptance criteria, readings taken during the portion of the day when results may have been inaccurate should be noted and qualified.
Responsible Person: Field Team Leader
SOP Reference: SOG NJ1, SOG NJ2, SOG NJ3, SOG NJ5

Turbidity Meter
Parameters: The groundwater sampling and monitoring will utilize turbidity meters to analyze for turbidity.
Calibration: Calibration will be performed using a three-point calibration curve in accordance with instrument instruction manuals and SOG NJ4. Ensure that calibration solutions are not past the expiration date prior to calibration. Expired solutions will not be used to calibrate instruments.
Maintenance: see SOG NJ4
Inspection: Equipment shall be inspected for defects upon receipt, prior to calibration, and periodically during sampling.
Frequency: Calibration is performed at the beginning of the day. Calibration checks will be done after initial calibration and at the end of the day. Testing and inspection should be done if there are any incidents which may cause damage to the unit.
Acceptance: see SOG NJ4
Corrective Action: If there is any indication that the equipment is broken or malfunctioning, it will be replaced or returned to the rental company for replacement.

Acronym list

SOG – Standard Operating Guideline

QAPP WORKSHEET #22: FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION (CONTINUED)

MINI RAE 2000 and 3000
Parameters: The mini RAE 2000 is a photoionization detector (PID) that generally measures VOCs such as isobutylene, hexane, xylene, benzene, styrene, toluene, and vinyl chloride, but can be calibrated to identify other volatile gases. The instrument will be used to evaluate work areas for health and safety and PPE requirements.
Calibration: Calibration should be performed at the beginning of each work day. The calibration will be a two-point curve including a "fresh air" calibration at 0.0 ppm and a span gas calibration at 100 ppm. Calibration procedures are outlined in the MiniRAE instruction manual. A correction factor may need to be used for certain gases (see MiniRAE user manual for more information). Lower and upper alarm limits should match criteria outlined in the Health and Safety Plan for PPE upgrade conditions (generally 5 ppm and 50 ppm, sustained). Calibration should be documented daily. Ensure that calibration span gas has not expired. Expired calibration gases should not be used to calibrate the PID.
Maintenance: Battery should be charged daily and will require replacing in the field when it can no longer recharge. PIDs are sensitive to moisture; therefore, a moisture/particulate filter should always be used, fitted on the PID intake. If the lamp or lamp housing becomes wet or soiled, these areas will require cleaning in accordance with the MiniRAE user manual. Additionally, filters will require replacement after use. Indications that a filter, particulate or vapor, requires replacement include: visible particulate matter, inability for unit to zero, tearing, or obstruction of flow (audible indication of pump straining). The PID digital display should be kept from overexposure to water and sunlight to maximize display longevity. Common replacement parts that will be immediately available during PID use are listed below: • Vapor filters; • Particulate filters; • AA batteries; and • Replacement lamps. All maintenance and corrective action activities should be appropriately documented on field forms and/or in field logbooks.

QAPP WORKSHEET #23: ANALYTICAL SOPS

Reference Number	Title	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
WI11475	*Multi-Parameters in Solids and Waters by Man-Tech Multi-Parameter System Rev 11; effective 3/21/19*	Definitive	Water	Man-Tech Multi-Parameter System	Eurofins Lancaster Laboratories Environmental	N
WI11483	*Colorimetric Sulfide in Waters (#0230), Sulfide as H2S (#10293 Calculation), Dissolved Sulfide in Water (#10499) by 4500-S2 B/C/D-2011, 4500-S2 F-2011, or EPA 376.2, Rev 17, effective 3/15/18*	Definitive	Water	UV Spec	Eurofins Lancaster Laboratories Environmental	N
QA-SOP11880	*Balance, Syringe, Pipette, and Labware Verification, Rev 9, effective 07/02/18*	Definitive	Maintenance	Balance	Eurofins Lancaster Laboratories Environmental	N
WI11519	*pH Probes and Meters, Rev 13, effective 10/13/16*	Definitive	Water and Solid	pH Meter	Eurofins Lancaster Laboratories Environmental	N
WI11626	*Determination of Inorganic anions by Ion Chromatography in Waters and Soil by EPA 300.0, SW 846 9056, and SW 846 9056A, Rev 22, effective 12/24/18*	Definitive	Water and Solid	IC	Eurofins Lancaster Laboratories Environmental	N
WI11511	*Orthophosphate (Colorimetric) by EPA 365.3 in Waters, Rev 12, effective 5/09/18*	Definitive	Water	UV Spectrophotometer	Eurofins Lancaster Laboratories Environmental	N

QAPP WORKSHEET #23: ANALYTICAL SOPS (CONTINUED)

Reference Number	Title	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
WI11637	*Determination of Total Organic Carbon, Dissolved Organic Carbon, and Inorganic Carbon in Water and Wastewater, Rev 16, effective 9/25/18*	Definitive	Water	TOC Analyzer	Eurofins Lancaster Laboratories Environmental	N
WI11598	*Total Dissolved Solids (TDS)(Gravimetric) by 2540C-2011 or EPA 160.1 in Waters and Wastewaters, Rev 16, effective 4/08/19*	Definitive	Water	NA	Eurofins Lancaster Laboratories Environmental	N
WI9796	*Volatile Hydrocarbons in Water by Method RSK-175 Modified and SW-846 8015 Using Headspace Sampling Techniques and GC-FID, Rev 18, effective 12/05/18*	Definitive	Dissolved Hydrocarbons	GC	Eurofins Lancaster Laboratories Environmental	N
WI9689	*Maintenance and Troubleshooting Procedures for GC/FID Instrumentation, Rev 8, effective 1/16/2015*	N/A	Maintenance	N/A	Eurofins Lancaster Laboratories Environmental	N
WI11933	*Metals by Inductively Coupled Plasma Mass Spectrometry for SW-846 Methods 6020/6020A/6020B (aqueous, solid, tissue), and EPA 200.8 (aqueous), Rev 8, effective 09/25/18*	Definitive	Solid, liquid, tissues Metals	ICP/MS	Eurofins Lancaster Laboratories Environmental	N
WI9989	*Perchlorate by Method 6850 in Waters and Solids by LC/MS/MS, Rev 13, effective 03/22/19*	Definitive	Perchlorate by LC/MS/MS	LC/MS/MS	Eurofins Lancaster Laboratories Environmental	N

QAPP WORKSHEET #23: ANALYTICAL SOPS (CONTINUED)

Reference Number	Title	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
WI10008	*Preventive and corrective HPLC Maintenance for the Pesticide Residue Analysis Department, Rev 6, effective 5/17/13*	NA	Maintenance	NA	Eurofins Lancaster Laboratories Environmental	N
ESTCP Project ER-200509 (Guidance Document)	*Guidance Manual for Forensic Analysis of Perchlorate in Groundwater using Chlorine and Oxygen Isotopic Analyses*[1]	Definitive	Waters	IRMS	Environmental Isotope Geochemistry Laboratory: University of Delaware	TBD

1. This guidance document is provided in the Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation, Appendix C. There is no SOP for CSIA sampling, protocols will be based on the provided guidance document with any updates required.
2. Potential modifications will be decided based on first round of sampling.

Acronym list

GC – gas chromatography
IC – ion chromatography
IRMS – isotope-ratio mass spectrometry
LC – liquid chromatograph
MS – mass spectrometer
TOC – total organic carbon

QAPP WORKSHEET #24: ANALYTICAL INSTRUMENT CALIBRATION

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA

Parameter	Calibration Procedure/Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
pH electrode: Alkalinity	Calibration using at least 3 points, sloped with pH 4, 7, and 10 buffers	Daily	percent slope between 92% and 102%	Correct the problem and recalibrate	ELLE Analyst	WI11475
	CCV Standard	After each calibration, every 10 samples, and end of batch	±10% D	Correct the problem, recalibrate and reanalyze affected samples		
Sulfide	Calibration using at least 5 points ranging from 0.10 to 2.0 mg/l	Every 3 months or when a new reagent is prepared	Correlation coefficient must be ≥0.995	Correct the problem and recalibrate	ELLE Analyst	WI11483
	CCV Standard	Beginning of each batch, every 10 samples, and end of batch	±10% D	Correct the problem, recalibrate and reanalyze affected samples		
IC Anions 300.0 or SW-846 9056	Initial calibration with a minimum of 5 points with a concentration span of 15x or 30x depending on the analyte	Every 60 days or when CCV fails	r >0.995; Level 1 standard must recover ≥50% of the true value	Perform more aggressive instrument maintenance and recalibrate	ELLE Analyst	WI11626
	ICB	After each initial calibration	No analytes detected > MDL	Correct problem and reanalyze the ICB. Recalibrate if needed.		
	ICV	After each initial calibration	Within +/- 10% of the nominal concentration	If ICV fails again do system maintenance and recalibrate.		
	CCV	Every 10 injections	Within +/- 10% of the nominal concentration	Recalibrate; reanalyze affected samples		
	CCB	Every 10 injections	No analytes detected > MDL	Recalibrate; reanalyze affected samples		

QAPP WORKSHEET #24: ANALYTICAL INSTRUMENT CALIBRATION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA

Parameter	Calibration Procedure/Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
UV Spectrophotometer	Initial Calibration with a minimum 5 points ranging from 0.1 mg/L to 0.8 mg/L.	Quarterly	Correlation Coefficient of >0.995	Recalibrate, perform instrument maintenance if calibration cannot conform to criteria, recalibrate	ELLE Analyst	WI11511, WI11495, WI11537
	ICV Standard	After each ICAL	±10% D	Reanalyze the ICV. If ICV fails again do system maintenance and recalibrate.		
	CCV Standard	Every 10 samples	±10% D	Reanalyze affected samples		
TOC Analyzer: TOC, DOC, & TIC in Water	Initial calibration with a minimum 6 points ranging from 1.0 ppm to 100 ppm	Monthly or after continuing calibration fails	$r^2 \geq 0.995$	Perform more aggressive instrument maintenance and recalibrate	ELLE Analyst	WI11637, WI11682
	ICB Standard	After each initial calibration	No analytes detected > LOQ	Perform more aggressive instrument maintenance and recalibrate		
	ICV Standard	After each initial calibration	Within +/- 10% of the nominal concentration	Reanalyze the ICV. If ICV fails again do system maintenance and recalibrate.		
	Total Inorganic Check Standard	Daily	Within +/- 20% of the nominal concentration	All affected samples are reanalyzed		
	CCV Standard	If instrument is idle > 4 hours, after every 10 field samples, and at the end of the sequence	Within +/- 10% of the nominal concentration	All affected samples are reanalyzed		
	CCB Standard	If instrument is idle > 4 hours, after every 10 field samples, and at the end of the sequence	No analytes detected > LOQ	All affected samples are reanalyzed		
Total Dissolved Solids	NA	NA	NA	NA	ELLE Analyst	WI11598

QAPP WORKSHEET #24: ANALYTICAL INSTRUMENT CALIBRATION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA

Parameter	Calibration Procedure/Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
Gas Chromatography Dissolved Hydrocarbons	Initial calibration with 6 points ranging from 2 ppb to 500 ppb depending on the compound	After continuing calibration fails	%RSD for ICAL ≤20%, linear r^2 ≥0.99	Perform more aggressive instrument maintenance and recalibrate	ELLE Analyst	WI9796
	MDL Standard	After each initial calibration	All compounds must be detected	Repeat initial calibration procedure prior to analyzing samples. Repeat maintenance if needed.		
	ICV Standard	After each initial calibration	Target compounds +/- 15% of the nominal concentration and within established retention time windows	Reanalyze the ICV. If ICV fails again do system maintenance and recalibrate.		
	CCV Standard	Prior to sample analysis, after every 10 field samples, and at the end of the sequence.	For RSK-175: Target compounds +/- 15% of the nominal concentration. For SW-846 8015C/D: Target compounds +/- 20% of the nominal concentration.	All samples since acceptable CCV must be reanalyzed. If the CCV fails high, any associated samples that are ND can be reported.		

QAPP WORKSHEET #24: ANALYTICAL INSTRUMENT CALIBRATION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA

Parameter	Calibration Procedure/Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
ICP/MS: 200.8	Tuning	Daily	No AMU diff. of >0.1 P.W. ≥0.64 and ≥0.66 (Elan 9000) or P.W. <0.9 at 10% height (Agilent); %RSD <5 for masses used for tuning	Perform mass calibration for AMU. Adjust mass calibration for P.W.	ELLE Analyst	WI11933
	Initial Calibration consists of Blank and 1 point: 0 and 10,000 ppb for Al, Ca, Fe, Mg, K, Na; 0 and 1,000 ppb for As, Ba, Cr, Co, Cu, Mn, Ni, Ti, V, Zn; 0 and 100 ppb for Sb, Be, Cd, Pb. Mo, Se, Ag, Sr, Tl, Sn	Each new run	Passing ICV and ICB	Recalibrate, perform instrument maintenance if calibration cannot conform to criteria, recalibrate		
	ICV	After each calibration	±10% of true value	Reanalyze		
	ICB	Immediately after the ICV	Less than 3x IDL	Positive result: accept sample results >10X the ICB or < 1/2 RL. Negative result: accept results >10x ICB. All other samples must be reanalyzed with compliant ICB		
	CCV	Immediately after the ICSAB and every 10 samples	±10% of true value	If the CCV is out of specification and the result is not < - LOQ, accept results that report as non-detect for the affected analyte(s). Results for the affected analyte(s) ≥ to the reporting limit must not be reported (reanalyze).		

QAPP WORKSHEET #24: ANALYTICAL INSTRUMENT CALIBRATION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA

Parameter	Calibration Procedure/Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
ICP/MS: 200.8 (continued)	CCB	Immediately after the CCV and every 10 samples	Less than 3x IDL	Positive result: accept sample results >10X the ICB or < 1/2 RL. Negative result: accept results >10x ICB. All other samples must be reanalyzed with compliant CCB	ELLE Analyst	WI11933
	Interference Check Sample	At the beginning of each run immediately following the LLC	± 20% of the true value for each analyte	Recalibrate		
	Low Level Check (LLC)	Beginning of each sequence and before the interference check samples	± 50% of the true value. Not applicable if sample concentrations are >10x the true value of the LLC.	Reanalyze the sample		
	Linear Range	Quarterly	±10% of true value	Samples > 90% of the linear range must be reanalyzed as a dilution		
HPLC/MS/MS Perchlorate 6850	Tuning	Required prior to analysis and at end of sequence.	The mass axis tolerances for unit width are 0.10, for wide width they are 0.60, for the widest width they are 1.25.	Clean spray chamber. If needed, perform maintenance on the MS and then retune	ELLE Analyst	WI9989
	Initial calibration with a minimum 5 points. Ranges from a standard at or near the reporting limits through 20x the first level	After continuing calibration fails	correlation coefficient ≥0.995.	Perform more aggressive instrument maintenance and recalibrate		
	MDL Standard	After each initial calibration	Perchlorate must be detected	Repeat initial calibration procedure prior to analyzing samples. Repeat maintenance if needed.		

QAPP WORKSHEET #24: ANALYTICAL INSTRUMENT CALIBRATION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA

Parameter	Calibration Procedure/Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
HPLC/MS/MS Perchlorate 6850 (continued)	ICV Standard	After each initial calibration	Within +/-15% of the nominal concentration and within established retention time windows	Reanalyze the ICV and samples associated with the non-compliant ICV. If ICV fails again do system maintenance, recalibrate, and reanalyze samples.	ELLE Analyst	WI9989
	CCV Standard	Prior to sample analysis, after every 10 field samples, and at the end of the sequence. Alternate between low- and mid-range concentrations	Within ±15% for mid-range and ±50% for low-range of the nominal concentration and within established retention time windows	All samples since acceptable CCV must be reanalyzed. If the CCV fails high, any associated samples that are ND can be reported.		

QAPP WORKSHEET #24: ANALYTICAL INSTRUMENT CALIBRATION (CONTINUED)

Laboratory: Environmental Isotope Geochemistry Laboratory: University of Delaware, Newark, DE

Parameter	Calibration Procedure/Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
Isotope Ratio Mass Spectrometer	CCV Standard	Prior to sample analysis, after every 4 field samples, and at the end of the sequence.	Within analytical uncertainty (typically ±0.5‰)	Reanalyze the CCV and associated samples.	University of Delaware Analyst	N/A
	ICV Standard (reference gas, O_2 and CH_3Cl)	After initial calibration and at least three times per day of analysis	Within analytical uncertainty (typically ±0.5‰)	Reanalyze the ICV		

Acronym list

AMU - Atomic Mass Unit
CCB - Continuing Calibration Blank
CCV - Continuing Calibration Verification
ICB - Initial Calibration Blank
ICP - Inductively Coupled Plasma
ICV - Initial Calibration Verification
IDL – Instrument Detection Limit
LLC – Low Level Check
LOQ – Limit of Quantitation
MDL – Method Detection Limit
mg/L – milligrams per Liter
MS – Mass Spectrometer
ND – None Detected
SOP – Standard Operating Procedure

QAPP WORKSHEET #25: ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
pH/ISE Meter	As needed replacement of components	Calibration checks	Visual inspection of components	As needed maintenance/calibration checks every 10 injections	90-110% for calibration checks	Recalibration	ELLE Analyst	WI11519
Analytical balance	Assure the balance is in a vibration-free area, is level, and the interior housing is clean.	Verification with ASTM certified weights	Visual inspection and weight verification	Each day of use	The reading must be ±0.1% or ±0.5mg, whichever is greater.	1) verify cleanliness of weights 2) remove balance from service and place a call to service firm 3) management must evaluate data generated since last acceptable reading to determine any potential impacts to data quality	ELLE analyst	QA-SOP-11880
Analytical balance	Annual calibration and maintenance	Annual calibration and maintenance	Annual calibration and maintenance	Annual	As per vendor's specifications in compliance with ISO certification	As per vendor's specifications in compliance with ISO certification	Professional calibration vendor (ISO 17025 certified)	QA-SOP-11880
IC	As needed replacement of components	Calibration checks	Visual inspection of components	As needed maintenance/calibration checks every 10 injections	90-110% for calibration checks (95-105% for method 218.6)	Recalibration	ELLE Analyst	WI11625

QAPP WORKSHEET #25: ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Total Organic Carbon Analyzer	As needed replacement of components	Calibration checks	Visual inspection of components	As needed maintenance/calibration checks every 10 injections	90-110% for calibration checks	Recalibration	ELLE Analyst	WI11637
HP5890, HP6890, or Agilent 7890 Gas Chromatograph with Flame Ionization Detector	Injection port maintenance; Column; FID maintenance	Continuing Calibration Check	Visual Inspection	As Needed	Initial Calibration within Specifications	Perform Maintenance again; re- calibrate if necessary	ELLE analyst	WI9689
Agilent 7500 CE	As needed replacement of components	Calibration checks	Visual inspection of components	As needed maintenance/ calibration checks every 10 injections	90-110% for the calibration checks	Recalibration	ELLE Analyst	WI11933
Agilent 1200 or HP 100 series LC/MS/MS or equivalent	Injection port maintenance; MS/MS detector maintenance	Calibration Check All analytes within +/- 15% of the nominal concentration and within established retention time windows	Visual Inspection	As needed	Initial calibration after maintenance is within specifications	Perform maintenance again	ELLE Analyst	WI10008

QAPP WORKSHEET #25: ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION (CONTINUED)

Laboratory: Environmental Isotope Geochemistry Laboratory: University of Delaware, Newark, DE

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Isotope Ratio Mass Spectrometer	Disassemble, clean, and reassemble ion source	Cleaning	Visual inspection of components	Annual	Initial calibration after maintenance is within specifications	Perform maintenance again	University of Delaware Analyst	N/A

Acronym list

ASTM- American Society for Testing and Materials
FID - Flame Ionization Detector
IC – Ion Chromatography
MS – Mass Spectrometer
SOP – Standard Operating Procedures

QAPP WORKSHEET #26: SAMPLE HANDLING, CUSTODY, AND DISPOSAL

Sample Collection, Packaging, and Shipment
Sample Collection (Personnel/Organization): Field Manager, Geosyntec
Sample Packaging (Personnel/Organization): Field Manager, Geosyntec
Coordination of Shipment (Personnel/Organization): Field Manager, Geosyntec
Type of Shipment/Carrier: Courier or overnight shipping

Sample Receipt and Analysis
Sample Receipt (Personnel/Organization): Sample Receiving Personnel, Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Sample Custody and Storage (Personnel/Organization): Sample Receiving Personnel, Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Sample Preparation (Personnel/Organization): Sample Receiving Personnel, Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Sample Determinative Analysis (Personnel/Organization): Sample Receiving Personnel, Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Sample Disposal
Personnel/Organization: Sample Receiving Personnel, Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Analysis: Field Samples are stored for 30 days after submittal of the completed data package.

QAPP WORKSHEET #26: SAMPLE HANDLING, CUSTODY, AND DISPOSAL (CONTINUED)

Sample Receipt and Analysis[1]
Sample Receipt (Personnel/Organization): Andrew Jackson, Civil and Environmental Engineering, Texas Tech University, 911 Boston, Box 41023, Lubbock, TX 79409-1023/ Sample Receiving Personnel, Environmental Isotope Geochemistry Laboratory: University of Delaware, Newark, DE
Sample Custody and Storage (Personnel/Organization): Andrew Jackson, Civil and Environmental Engineering, Texas Tech University, 911 Boston, Box 41023, Lubbock, TX 79409-1023/ Sample Receiving Personnel, Environmental Isotope Geochemistry Laboratory: University of Delaware, Newark, DE
Sample Preparation (Personnel/Organization): Andrew Jackson, Civil and Environmental Engineering, Texas Tech University, 911 Boston, Box 41023, Lubbock, TX 79409-1023/ Sample Receiving Personnel, Environmental Isotope Geochemistry Laboratory: University of Delaware, Newark, DE
Sample Determinative Analysis (Personnel/Organization): Andrew Jackson, Civil and Environmental Engineering, Texas Tech University, 911 Boston, Box 41023, Lubbock, TX 79409-1023/ Neil Sturchio, Environmental Isotope Geochemistry Laboratory: University of Delaware, Newark, DE
Sample Disposal
Personnel/Organization: Sample Receiving Personnel, Environmental Isotope Geochemistry Laboratory: University of Delaware, Newark, DE,
Analysis: Field Samples are stored for 30 days after submittal of the completed data package.

1. Extractions and Purification of CSIA samples occur at Texas Tech University Laboratory and Isotope Analyses are performed at the University of Delaware.

QAPP WORKSHEET #27: SAMPLE CUSTODY REQUIREMENTS

Chain-of-Custody Procedures:

Field sample personnel will use standard sample custody procedures to maintain and document sample integrity during collection, transportation, storage, and analysis. A sample will be considered to be in custody if one of the following statements applies:

- It is in a person's physical possession or view;
- It is in a secure area with restricted access; or
- It is placed in a container and secured with an official seal so that the sample cannot be reached without breaking the seal.

Chain of custody procedures provide an accurate written record that traces the possession of individual samples from the time of collection in the field to the time of acceptance at the laboratory. The chain of custody record will also be used to document the samples collected and the analyses requested. Information that the field personnel will record on the chain of custody record includes:

- Project name and number;
- Sampling location;
- Name of sampler;
- Destination of samples (laboratory name);
- Sample identification number;
- Date and time of collection;
- Number of containers filled;
- Analysis requested;
- Preservatives used (if applicable);
- Filtering (if applicable);
- Sample designation (grab or composite);
- Signatures of individuals involved in custody transfer, including the date and time of transfer; and
- Project contact and email address.

Field personnel will sign chain of custody records that are initiated in the field, and the air bill number will be recorded if applicable. The record will be placed in a waterproof plastic bag and taped to the inside of the shipping container used to transport the samples. Signed air bills will serve as evidence of custody transfer between field personnel and the courier, and between the courier and the laboratory. Copies of the chain of custody record and the air bill, if applicable, will be retained and filed by field personnel before the containers are shipped.

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory):

The following procedures will be implemented when samples collected during this project are shipped via laboratory courier or overnight shipping service:

- Confirm that sample labels are securely affixed to sample containers.
- Check the caps on the sample containers to confirm that they are properly sealed.

QAPP WORKSHEET #27: SAMPLE CUSTODY REQUIREMENTS (CONTINUED)

- Complete the COC form with the required sampling information and confirm that the recorded information matches the sample labels. The appropriate personnel will sign and date the COC form to document the sample custody transfer.
- Wrap sample containers in bubble wrap or other cushioning material.
- Place cushioning material at the bottom of the cooler.
- Place the sealed sample containers and a temperature blank in the cooler.
- Place a sufficient amount of wet ice in the cooler to maintain a sample temperature of <6°C.
- Fill the remaining space in the cooler with cushioning material.

The following procedures will be implemented only when shipping via an overnight shipping service.

- Place the COC forms in plastic bags and seal. Tape the forms to the inside of the appropriate cooler lid.
- Close the cooler lid and secure with tape.
- Wrap tape around both ends of the cooler and attach custody seals to the cooler and cover with clear protective tape.
- Mark the cooler on the outside with the following information: Shipping address, return address, "Fragile" labels, and arrows indicating "This side up." Place a signed custody seal over the cooler lid.

Laboratory Sample Custody Procedures (receipt of samples, archiving, and disposal):

Laboratory COC begins when samples are received and continues until samples are discarded. Sample custodians will receive the incoming samples, sign the accompanying COC forms, and retain copies of the COC forms as permanent records. The laboratory sample custodians will record the pertinent information concerning the samples, including the persons delivering the samples, the date and time received, sample condition at the time of receipt (sealed, unsealed, or broken container; temperature at laboratory receipt; or other relevant remarks), the sample identification numbers, and the unique laboratory identification numbers for the samples. This information should be entered into a computerized laboratory information management system (LIMS). The laboratory is responsible for maintaining records necessary to maintain custody throughout sample preparation and analysis.

The laboratory will provide a secure storage area for the samples. Access to this area will be restricted to authorized personnel. The custodian will confirm that samples requiring special handling, including samples that are heat- or light-sensitive, radioactive, or have other unusual physical characteristics, will be properly stored and maintained prior to analysis. Laboratory SOPs for sample custody, tracking, archiving and disposal are located at the laboratory and are available upon request.

QAPP WORKSHEET #27: SAMPLE CUSTODY REQUIREMENTS (CONTINUED)

Sample Identification Procedures:

A sample numbering system will be used to identify each sample collected for laboratory analysis. The numbering system will ensure that each sample is uniquely identified and will allow for retrieval of sample information about a particular sample location from a database. Parent samples and quality control samples will use the following formats for sample IDs:

Parent Sample	Well ID_YYYYMMDD	Ex: SC36D_20190731
Duplicate	DUP-XX	Ex: DUP-01
Matrix Spike	Well ID_ YYYYMMDD_MS	Ex: SC36D_20190731_MS
Matrix Spike Duplicate	Well ID_ YYYYMMDD_MSD	Ex: SC36D_20190731_MSD
Equipment Blank	EB_ YYYYMMDD	Ex: EB_20190731
Field Blank	FB_ YYYYMMDD	Ex: FB_20190731
Trip Blank	TB_ YYYYMMDD	Ex: TB_20190731

The sample identification given to duplicate samples will be consecutively numbered blind duplicate IDs, the project name, project number, preservative and date collected will be the only identifying information on the label, the time, well identification and sampler's initials sections of the label will all be left blank.

Duplicate sample example: duplicate for a groundwater sample collected from SC20S as the second duplicate of the sampling event on 25 September 2017 would be as follows: DUP-02.

Sample Labels

A sample label will be affixed to the sample containers, appropriate for the site and sample location. The label will be completed with the following information:

- Project name;
- Sample identification number;
- Date and time of sample collection;
- Preservative used (if applicable);
- Sample collector's initials.

Sample Documentation

Documentation during sampling is essential to confirm proper sample identification. Field personnel will adhere to the following general guidelines for maintaining field documentation:

- Documentation will be completed in permanent ink.
- All entries will be legible.
- Errors will be corrected by crossing out with a single line and then dating and initialing the lineout.
- Any serialized documents will be maintained in the project file and referenced in the site logbook.
- Unused portions of pages will be crossed out, and each page will be signed and dated.

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Alkalinity
Analytical Method/SOP: SM 2320B-1997 or EPA 310.1; WI11475

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Method blank	1 per prep batch of up to 20 samples	No analytes detected > LOQ or >1/10 the amount measured in any sample	Reanalyze blank to confirm detections. If detects confirm, reanalyze samples that are not ND or not >10x the blank value.	ELLE Analyst	See Worksheet #12
LCS	1 per prep batch of up to 20 samples	Laboratory statistical window (82-106%) and RPD, whichever is tighter	Reanalyze LCS and associated samples. Analytes in the LCS that fail high and are ND in the samples can be reported. All others are re-analyzed.	ELLE Analyst	See Worksheet #12
Laboratory Duplicate	1 per 10 samples	Laboratory statistical RPD	Flag data	ELLE Analyst	See Worksheet #12
Field Duplicate	1 per 20 samples	RPD <30%	Flag Data	Geosyntec Project QAM	See Worksheet #12
Equipment Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12
Field Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

Acronym list

LCS – Laboratory Control Sample

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Alkalinity (continued)
Analytical Method/SOP: SM 2320B-1997 or EPA 310.1; WI11475

Acronym list (continued)
LOQ – Limit of Quantification
MPC - Measurement Performance Criteria
ND – None Detected
RPD – Relative Percent Difference
SOP – Standard Operating Procedures

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Sulfide
Analytical Method/SOP: SM 4500 S2D/EPA 376.2; WI11483

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Method blank	1 per prep batch of up to 20 samples	No analytes detected > 1/2 LOQ or >1/10 the amount measured in any sample	Reanalyze blank to confirm detections. If detects confirm, reanalyze samples that are not ND or not >10x the blank value.	ELLE Analyst	See Worksheet #12
Matrix Spike	1 per 20 samples	Laboratory statistical or method window (90-100%) and RPD, whichever is tighter	Flag outliers	ELLE Analyst/ Geosyntec Project QAM	See Worksheet #12
LCS	1 per prep batch of up to 20 samples	Laboratory statistical or method window (90-100%) and RPD, whichever is tighter	Reanalyze LCS and associated samples. Analytes in the LCS that fail high and are ND in the samples can be reported. All others are re-analyzed.	ELLE Analyst	See Worksheet #12
Laboratory Duplicate	1 per 10 samples	Laboratory statistical RPD	Flag data	ELLE Analyst	See Worksheet #12
Field Duplicate	1 per 20 samples	RPD <30%	Flag Data	Geosyntec Project QAM	See Worksheet #12
Equipment Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Sulfide (continued)
Analytical Method/SOP: SM 4500 S2D/EPA 376.2; WI11483

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Field Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

Acronym list

LCS – Laboratory Control Sample
LOQ – Limit of Quantification
MPC - Measurement Performance Criteria
ND – None Detected
RPD – Relative Percent Difference
SOP – Standard Operating Procedures

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Wet Chemistry – Inorganic Ions by IC (NO3 and SO4)
Analytical Method/SOP: EPA 300.0/9056; WI11626

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Method blanks	1 per prep batch of up to 20 samples	No analytes detected <MDL or >1/10 the amount measure in any sample.	Reanalyze to confirm detections. If detects confirm re-extract samples that are not ND or not >10x the blank value	ELLE Analyst	See Worksheet #12
Matrix Spike	1 per 20 samples	Laboratory statistical (90-110%)	Flag outliers	ELLE Analyst/ Geosyntec Project QAM	See Worksheet #12
LCS	1 per prep batch of up to 20 samples	Laboratory statistical (90-110%)	Reanalyze LCS and associated samples. Analytes in the LCS that fail high and are ND in the samples can be reported. All others are re-extracted.	ELLE Analyst	See Worksheet #12
Laboratory Duplicate	1 per 10 samples	Laboratory statistical (15%)	Flag outliers	ELLE Analyst	See Worksheet #12
Field Duplicate	1 per 20 samples	RPD <30%	Flag Data	Geosyntec Project QAM	See Worksheet #12
Equipment Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12
Field Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Wet Chemistry – Inorganic Ions by IC (NO3 and SO4) (continued)
Analytical Method/SOP: EPA 300.0/9056; WI11626

Acronym list

LCS – Laboratory Control Sample
LOQ – Limit of Quantification
MPC - Measurement Performance Criteria
ND – None Detected
RPD – Relative Percent Difference
SOP – Standard Operating Procedures

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Orthophosphate as Phosphorous
Analytical Method/SOP: EPA 365.3; WI11511

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Method blank	1 per prep batch of up to 20 samples	No analytes detected > LOQ or >1/10 the amount measured in any sample	Reanalyze blank to confirm detections. If detects confirm, reanalyze samples that are not ND or not >10x the blank value.	ELLE Analyst	See Worksheet #12
Matrix Spike	1 per 20 samples	Laboratory statistical windows (95-105%)	Flag outliers	ELLE Analyst/ Geosyntec Project QAM	See Worksheet #12
LCS	1 per prep batch of up to 20 samples	Laboratory statistical windows (95-105%)	Reanalyze LCS and associated samples. Analytes in the LCS that fail high and are ND in the samples can be reported. All others are re-analyzed.	ELLE Analyst	See Worksheet #12
Laboratory Duplicate	1 per 20 samples	Laboratory statistical RPD	Flag data	ELLE Analyst	See Worksheet #12
Field Duplicate	1 per 20 samples	RPD <30%	Flag Data	Geosyntec Project QAM	See Worksheet #12
Equipment Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Orthophosphate as Phosphorous (continued)
Analytical Method/SOP: EPA 365.3; WI11511

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Field Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

Acronym list

LCS – Laboratory Control Sample
LOQ – Limit of Quantification
MPC - Measurement Performance Criteria
ND – None Detected
RPD – Relative Percent Difference
SOP – Standard Operating Procedures

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Total Organic Carbon
Analytical Method/SOP: SM 5310C/EPA 415.1; WI11637

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Method blanks	1 per prep batch of up to 20 samples	No analytes detected 1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater	Reanalyze blank to confirm detections. If detects confirm, re-prep samples that are not ND or not >10x the blank value.	ELLE Analyst	See Worksheet #12
Matrix Spike	1 per 20 samples	Laboratory statistical limits for compounds and RPD (91-113%)	Flag outliers	ELLE Analyst/ Geosyntec Project QAM	See Worksheet #12
LCS	1 per prep batch of up to 20 samples	Laboratory statistical limits for compounds and RPD (91-113%)	Correct problem, re-prepare and reanalyze the LCS and all sample associated	ELLE Analyst	See Worksheet #12
Laboratory Duplicate	1 per 10 samples	Laboratory statistical RPD	Flag data	ELLE Analyst	See Worksheet #12
Field Duplicate	1 per 20 samples	RPD <30%	Flag Data	Geosyntec Project QAM	See Worksheet #12
Equipment Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12
Field Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Total Organic Carbon (continued)
Analytical Method/SOP: SM 5310C/EPA 415.1; WI11637

Acronym list

LCS – Laboratory Control Sample
LOQ – Limit of Quantitation
MPC - Measurement Performance Criteria
ND – None Detected
RPD – Relative Percent Difference
SOP – Standard Operating Procedures

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Total Dissolved Solids (TDS)
Analytical Method/SOP: SM 2540 C-2011; WI11597

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Method blank	1 per prep batch of up to 20 samples	No analytes detected > LOQ or >1/10 the amount measured in any sample	Reanalyze blank to confirm detections. If detects confirm, re-prep samples that are not ND or not >10x the blank value.	ELLE Analyst	See Worksheet #12
LCS	1 per prep batch of up to 20 samples	Laboratory statistical windows (72-127%)	Correct problem, re-prepare and reanalyze the LCS and all sample associated	ELLE Analyst	See Worksheet #12
Laboratory Duplicate	1 per 10 samples	Method Relative Percent Difference	Flag data	ELLE Analyst	See Worksheet #12
Field Duplicate	1 per 20 samples	Relative Percent Difference <30%	Flag Data	Geosyntec Project QAM	See Worksheet #12
Equipment Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12
Field Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

Acronym list

LCS – Laboratory Control Sample
LOQ – Limit of Quantitation
MPC - Measurement Performance Criteria
ND – None Detected
SOP – Standard Operating Procedures

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Dissolved Hydrocarbons (Methane, Ethane, Ethene)
Analytical Method/SOP: RSK175 or SW-846 8015C or D/WI9796

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Surrogate Spike	Per Sample (including Blanks, LCS/D, MS/D	Laboratory statistical limits (methane: 73-125%, ethane: 74-131%, ethene: 72-133%)	Reanalyze if outside limits, if confirmed, report	ELLE Analyst	See Worksheet #12
Method Blanks	1 per prep batch of up to 15 samples	No analytes detected > RL or >1/10 the amount measured in any sample	Reanalyze to confirm detections	ELLE Analyst	See Worksheet #12
Matrix Spike	1 per prep batch of up to 20 samples	Laboratory statistical limits (methane: 73-125%, ethane: 74-131%, ethene: 72-133%), RPD ≤30%	Flag outliers	ELLE Analyst/ Geosyntec Project QAM	See Worksheet #12
LCS/D	1 per prep batch of up to 15 samples	Laboratory statistical limits (methane & ethane: 85-115%, ethene: 83-115%), RPD ≤20%	Reanalyze LCS and associated samples. Analytes in the LCS that fail high and are ND in the samples can be reported.	ELLE Analyst	See Worksheet #12
Field Duplicate	1 per 20 samples	RPD <30%	Flag Data	Geosyntec Project QAM	See Worksheet #12
Equipment Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Field Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Dissolved Hydrocarbons (Methane, Ethane, Ethene) (continued)
Analytical Method/SOP: RSK175 or SW-846 8015C or D/WI9796

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Trip Blank	1 per cooler	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

Acronym list

LCS/D – Laboratory Control Sample/ Duplicate
MPC - Measurement Performance Criteria
ND – None Detected
RL – Reporting Limit
RPD – Relative Percent Difference
SOP – Standard Operating Procedures

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Metals (Total and Dissolved Iron)
Analytical Method/SOP: EPA 200.8 WI11933

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Method Blank	1 per prep batch of up to 20 samples	No analytes detected > 1/2 LOQ or 2.2x MDL, whichever is greater, or >1/10 the amount measured in any sample.	Reanalyze blank to confirm detections. If detects confirm, re-digest samples that are not ND or not >10x the blank value.	ELLE Analyst	See Worksheet #12
Matrix Spike	1 per prep batch of up to 20 samples	Recovery limits 70 - 130%; RPD ≤20%	Analyze post digestion spike and serial dilution	ELLE Analyst/ Geosyntec Project QAM	See Worksheet #12
LCS/LCSD	1 per prep batch of up to 20 samples	Recovery limits 85 - 115%; RPD ≤20%	Analytes in the LCS that fail high and are ND in the samples can be reported. All others are re-digested and reanalyzed.	ELLE Analyst	See Worksheet #12
Laboratory Duplicate	1 per prep batch of up to 20 samples	RPD must be ≤20%	Flag data	ELLE Analyst	See Worksheet #12
Serial Dilutions	Must be prepared with each background sample, evaluated only when analyte concentrations are >50x the MDL	The percent difference must be ≤10%	Flag data	ELLE Analyst	See Worksheet #12

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Metals (Total and Dissolved Iron) (continued)
Analytical Method/SOP: EPA 200.8 WI11933

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Post Digestion Spike (PDS)	Prepare with each background sample	± 15% True Value	No specific action needed unless required by the project. PDS is reported in data package	ELLE Analyst	See Worksheet #12
Field Duplicate	1 per 20 samples	RPD <30%	Flag Data	Geosyntec Project QAM	See Worksheet #12
Equipment Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12
Field Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

Acronym list

LCS/LCSD – Laboratory Control Sample / Laboratory Control Sample Duplicate
LOQ – Limit of Quantitation
MPC - Measurement Performance Criteria
MDL - Method Detection Limit
ND – None Detected
PDS - Post Digestion Spike
RPD – Relative Percent Difference
SOP – Standard Operating Procedures

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Matrix: Groundwater
Analytical Group: Perchlorates
Analytical Method/SOP: SW-846 6850/WI9989

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Method blanks	1 per prep batch of up to 20 samples	No analytes detected > RL or >1/10 the amount measured in any sample	Reanalyze to confirm detections. If detects confirm reextract samples that are not ND or not >10x the blank value	ELLE Analyst	See Worksheet #12
Matrix Spike	1 per prep batch of up to 20 samples	Laboratory statistical limits (80-120%)	Flag outliers	ELLE Analyst/ Geosyntec Project QAM	See Worksheet #12
LCS/LCSD	1 per prep batch of up to 20 samples	Laboratory statistical limits (80-120%)	Analytes in the LCS that fail high and are ND in the samples can be reported. All others are re-extracted.	ELLE Analyst	See Worksheet #12
Field Duplicate	1 per 20 samples	RPD <30%	Flag Data	Geosyntec Project QAM	See Worksheet #12
Equipment Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12
Field Blank	1 per day or 1 per 20 samples whichever is greater	No detected target compounds	Flag Data	Geosyntec Project QAM	See Worksheet #12

Acronym list

LCS/LCSD – Laboratory Control Sample / Laboratory Control Sample Duplicate
MPC - Measurement Performance Criteria
ND – None Detected
RL – Reporting Limit
SOP – Standard Operating Procedures

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (CONTINUED)

Laboratory: Environmental Isotope Geochemistry Laboratory: University of Delaware, Newark, DE
Matrix: Groundwater
Analytical Group by Method/SOP: CSIA Perchlorate analysis[1]

QC Sample	Number/Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/position of person responsible for corrective action	Project-Specific MPC
Laboratory Duplicate	1 per prep batch of up to 10 samples	Within analytical uncertainty (typically ±0.5‰)	Flag outliers	University of Delaware Analyst	See Worksheet #12
Field Duplicate	1 per 10 samples	RPD <30%	Flag Data	Geosyntec Project Quality Assurance Manager	See Worksheet #12

1. There is no SOP for CSIA sampling, protocols will be based on the Environmental Isotope Geochemistry Laboratory Instructions for Perchlorate Collection Field Columns (Appendix C of the Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation) with any updates required.

QAPP WORKSHEET #29: PROJECT DOCUMENTS AND RECORDS

Document	Where Maintained
Field Records: Field logbooks, COC records/forms, QAPP deviations, communications and reports, photographs, GPS printouts	Maintained at Geosyntec until after completion of the project. Files will be archived at Geosyntec project office and included in reports submitted to USEPA.
Laboratory Analytical Records: Raw and summary data, COC and sample receipt forms, sample and instrument logs	Maintained at Geosyntec until after completion of the project. Files will be archived at Geosyntec project office and included in reports submitted to USEPA.
Data Assessment and QA Records: Data validation report, independent technical review forms, CA communications and reports	Maintained at Geosyntec until after completion of the project. Files will be archived at Geosyntec project office and included in reports submitted to USEPA.
Reports: Drafts, final reports, communications of progress and deviations	Maintained at Geosyntec until after completion of the project. Files will be archived at Geosyntec project office and included in reports submitted to USEPA.

Documents and Records

Documentation is critical for evaluating the success of any environmental data collection activity. The following sections discuss the requirements for documenting field activities and for preparing laboratory data packages. This worksheet also lists documents and reports that will be generated as a result of this project.

Field Documentation

Complete and accurate documentation is essential to demonstrate that field measurement and sampling procedures are carried out as described in this QAPP. Field personnel will use permanently bound field logbooks with sequentially numbered pages to record and document field activities. The field logbook will list the contract name and number, the site name, and the names of subcontractors, the service client, and the Project Manager. At a minimum, the following information will be recorded in the field logbook:

- Name and affiliation of all onsite personnel or visitors;
- Weather conditions during the field activity;
- Summary of daily activities and significant events;
- Notes of conversations with coordinating officials;
- References to other field logbooks or forms that contain specific information;
- Discussions of problems encountered and the resolution;
- Discussions of deviations from the QAPP or other governing documents; and
- Description of all photographs taken.

If significant changes to the sampling program are needed because of unanticipated site conditions, this QAPP will need to be amended and submitted to the USEPA Region 2 for review and approval. The field logbook will provide documentation of the deviation from this QAPP and a brief rationale.

QAPP WORKSHEET #29: PROJECT DOCUMENTS AND RECORDS (CONTINUED)

Laboratory Documentation and Data Packages

The analytical laboratory performing analysis will provide full data packages, which contain the information required for data validation. The data packages must contain any of the following elements that are applicable to the analysis to enable data validation:

- Title page;
- Table of contents;
- Data package narrative;
- Final data report tables;
- Analytical records:
  - Instrument tuning (GC/MS methods);
  - RTs and RT windows for GC/ECD analyses;
  - Calibration data;
  - Calibration verifications;
  - Surrogate recoveries (GC/MS and GC methods);
  - Internal standard RT checks and area counts for GC/MS analyses and internal standard recoveries for ICP/MS analyses;
  - The QC data required by the analytical method and/or the QAPP (blanks, LCS/LCSD, MS/MSD, and laboratory and field duplicates);
  - Chromatograms for GC/ECD and GC/MS samples, calibrations, and QC samples;
  - Mass spectra for GC/MS analyses;
  - Required supporting information;
  - The sample custody documentation, including sample receipt forms;
  - Sample processing and spiking records;
  - Copies of standard preparation logs for each standard used in sample preparation and instrument calibration;
  - Run logs;
  - Raw data associated with field and QC data;
  - Chromatograms
- Documentation of manual integrations;
- List of current MDLs and RLs for the preparation and analysis methods used for sample processing.

QAPP WORKSHEET #29: PROJECT DOCUMENTS AND RECORDS (CONTINUED)

Data Package Format

The analytical laboratory will provide electronic data deliverables (EDDs) for each analytical report. An automated laboratory information management system (LIMS) must be used to produce the EDDs. Manual creation of the deliverable (data entry by hand) is unacceptable. The laboratory will verify EDDs internally before they are issued. The EDDs will correspond exactly to the hard-copy data. No duplicate data will be submitted. EDDs will be delivered in the appropriate format per USEPA Region 2 requirements as applicable. Data will be archived by the laboratory and by the Project Coordinator's office for a minimum of 10 years.

QAPP WORKSHEET #30: ANALYTICAL SERVICES

Matrix	Analytical Group	Concentration Level	Sample Locations/ID Number	Analytical SOP or Method	Data Package Turnaround Time	Laboratory / Organization (name and address, contact person and telephone number)	Backup Laboratory / Organization (name and address, contact person and telephone number)
Groundwater	Perchlorate	Low	See Worksheet #18	WI9989	28 Days	Eurofins Lancaster Laboratories Environmental, LLC 2425 New Holland Pike Lancaster, PA 17601 (717) 556-7290 Certification #PA011; certification is current	SGS North America 2235 US Highway 130 Dayton, NJ 08810 (732) 329-0200
Groundwater	Nitrate	Low		WI11626	Standard (10-15 business days)		
Groundwater	Sulfate	Low		WI11626			
Groundwater	Orthophosphate as Phosphorous	Low		WI11511			
Groundwater	Alkalinity	Low		WI11475			
Groundwater	TOC	Low		WI11637			
Groundwater	TDS	Low		WI11597			
Groundwater	Sulfide	Low		WI11483			
Groundwater	Iron (Total and Dissolved)	Low		WI11933			
Groundwater	Methane	Low		WI9015178			
Groundwater	Ethane	Low		WI9015178			
Groundwater	Ethene	Low		WI9015178			

Acronym list

DOC - Dissolved Organic Carbon
NA - Not Applicable
SOP – Standard Operating Procedures
TDS – Total Dissolved Solids
TOC – Total Organic Carbon

QAPP WORKSHEET #30: ANALYICAL SERVICES (CONTINUED)

Matrix	Analytical Group	Concentration Level	Sample Locations/ID Number	Analytical SOP or Method	Data Package Turnaround Time	Laboratory / Organization (name and address, contact person and telephone number)	Backup Laboratory / Organization (name and address, contact person and telephone number)
Groundwater	CSIA	Low	See Worksheet #18	ESTCP: Guidance Manual for Forensic Analysis of Perchlorate in Groundwater using Chlorine and Oxygen Isotopic Analyses[1]	Standard (90-120 days)	Environmental Isotope Geochemistry Laboratory: University of Delaware, 221 Academy St, ISE lab 458, Newark DE 19716 (302) 831-8022	NA
Groundwater	Gene-Trac®	NA	See Worksheet #18	Gene-Trac®	Standard (10 business days)	SiREM	NA

1. This guidance document is provided in the Revised Field Sampling Plan for OU3 Supplemental Remedial Investigation, Appendix C. There is no SOP for CSIA sampling, protocols will be based on the provided guidance document with any updates required

Acronym list

DOC - Dissolved Organic Carbon
NA - Not Applicable
SOP – Standard Operating Procedures
TDS – Total Dissolved Solids
TOC – Total Organic Carbon

QAPP WORKSHEET #31: PLANNED PROJECT ASSESSMENTS

Assessment Type	**Frequency**	**Internal or External**	**Organization Performing Assessment**	**Person(s) Responsible for Performing Assessment** (title and organizational affiliation)	**Person(s) Responsible for Responding to Assessment Findings** (title and organizational affiliation)	**Person(s) Responsible for Identifying and Implementing Corrective Actions (CA)** (title and organizational affiliation)	**Person(s) Responsible for Monitoring Effectiveness of CA** (title and organizational affiliation)
Offsite Laboratory Technical Systems Audit	Per Laboratory QA Manual	Internal	Eurofins Lancaster Laboratories Environmental	Per Laboratory QA Manual	Per Laboratory QA Manual	Laboratory Personnel	Per Laboratory QA Manual
Data Quality Assessment (data validation reports)	Upon receipt of analytical data packages	Internal	Geosyntec	Analytical Data QA Manager	Laboratory PM, Eurofins Lancaster Laboratories Environmental	Laboratory	Analytical Data QA Manager

Acronym list
QA – Quality Assurance

QAPP WORKSHEET #32: ASSESSMENT FINDINGS AND CORRECTIVE ACTION RESPONSES

Assessment Type	**Nature of Deficiencies Documentation**	**Individual(s) Notified of Findings** (name, title, organization)	**Timeframe of Notification**	**Nature of Corrective Action Response Documentation**	**Individual(s) Receiving Corrective Action Response** (name, title, organization)	**Timeframe for Response**
Offsite Laboratory Technical Systems Audit	Internal Audit Report	Laboratory Manager/ Laboratory Technical Director/ Laboratory Operations Manager	Annual audit	Per Individual Laboratory QA Manual	Analytical Data QA Manager	Per Individual laboratory QA Manual
Data Quality Assessment	Data Validation Report	Project QA Manager- Livia Capaldi	Upon receipt of analytical data package	Corrective Action from Laboratory	Project Manager- Seth Kellogg Project QA Manager- Livia Capaldi	Within two weeks of issuance of DQAR

Acronym list
DQAR – Data Quality Assessment Report
QA – Quality Assurance

QAPP WORKSHEET #32: ASSESSMENT FINDINGS AND CORRECTIVE ACTION RESPONSES (CONTINUED)

ASSESSMENT

This worksheet addresses assessment of the effectiveness of the project implementation and the associated QA/QC activities.

Field Assessment and Response Actions

To monitor the capability and performance of the field activities, field inspections will be performed as follows.

The Field Manager will supervise work activities and ensure that they are performed in accordance with plans and specifications. Any problems or concerns will be immediately discussed with the Geosyntec project manager, the client respondent and USEPA Region 2 RPM as appropriate. An appropriate corrective action (CA) developed, reviewed and implemented. The CA will be documented.

Equipment Inspections

Documented inspections will be performed daily on all equipment prior to and during their use to ensure the equipment is in safe operating condition. Field Personnel will perform these inspections and will alert the field manager immediately if an issue arises.

Preventative maintenance procedures recommended by the manufacturer will be followed. Any equipment found to be unsafe will be flagged and its use prohibited until unsafe conditions have been corrected. Replacement equipment will be delivered to site as quickly as possible if a piece of equipment is discovered to be faulty.

Verification and Testing Procedures

Non-conformance/CA

Non-conforming items and activities are those that do not meet the project requirements. When such a condition is identified, Geosyntec will implement a CA program to:

- Document the non-conforming item or procedure and determine the cause of the non-conformance and its effect on project performance and the integrity of completed work;
- Correct or replace the non-conforming item in the most efficient and effective manner; and
- Verify and document that the corrective action taken is successful.

Documentation of Non-Conforming Items

The Field Manager will document any non-conforming item in the field logbook. This list will clearly state what is out of compliance, the date the noncompliance was originally discovered, and the date the work was corrected.

QAPP WORKSHEET #32: ASSESSMENT FINDINGS AND CORRECTIVE ACTION RESPONSES (CONTINUED)

Implementation of CA

Geosyntec will stop work on any item or feature pending satisfactory correction of the deficiency noted by the Project Manager or the USEPA Region 2 RPM. The Project Manager and Field Manager will have the authority to stop work until CAs are implemented. In some cases, the CA may be obvious and may be implemented immediately upon identification of the non-conformance. Others may require additional input from technical and/or operations staff, additional equipment and/or materials, or changes in existing structures or completed work. The Project Manager and Field Manager will not allow work to be added to or built upon non-conforming work unless the USEPA Region 2 RPM concurs that the correction can be made without disturbing continuing work.

Verification and Documentation of CA

Non-Conformance/QC Reporting

A non-conformance is defined as an identified or suspected deficiency or discrepancy with regard to an approved document (e.g., improper sampling procedures, improper instrument calibration, calculation error); or an item where the quality of the end product itself or subsequent activities using the document or item would be affected by the deficiency; or an activity that is not conducted in accordance with the established plans or procedures.

Any team member engaged in project work that discovers or suspects a non-conformance is responsible for informing the Project Manager or Field Manager. The Project Manager will evaluate each non-conformance and provide a disposition, which describes the actions to be taken and notify the USEPA Region 2 RPM per the communication pathway time frame specified by this QAPP.

The Project Manager or Field Manager will verify that no further project work that is dependent on the non-conforming item or activity is performed until the situation has been corrected back to the original condition intended by the project documentation. Documentation of the non-conformance and CA, along with the appropriate verification and approval signatures, will be included in the project file. Copies of the non-conformances will be maintained by the Project Manager.

The Field Manager will verify successful completion of CAs for non-conformances on a follow-up inspection. The Weekly Activity Report will reflect all CAs completed. The Field Manager will also update the re-work item list with the CA taken and the date the CA was completed. Recurring non-conformances of similar nature will be investigated to determine the root cause of the problem so as to eliminate or minimize future occurrences of the non-conformance.

INTERNAL LABORATORY AUDITS

As part of its QA program, the laboratory QA manager will conduct audits of the analytical systems to verify that the systems are working properly, and personnel are adhering to established procedures and documentation practices. These audits will also assist in determining or detecting where problems are occurring. In addition to conducting internal audits, as part of its established QA program, the laboratory is required to take part in regularly scheduled semi-annual performance evaluation (PE) studies and laboratory audits from state and federal agencies, as defined by the agencies. Each laboratory selected to support this project must maintain current NELAP accreditation.

QAPP WORKSHEET #32: ASSESSMENT FINDINGS AND CORRECTIVE ACTION RESPONSES (CONTINUED)

Laboratory CAs

If a particular laboratory analysis is deemed “out of control,” CA will be taken by the laboratory to maintain continued data quality. Each laboratory must adhere to their in-house CA policy.

QAPP WORKSHEET #33: QA MANAGEMENT REPORTS TABLE

Type of Report	**Frequency** (Daily, weekly monthly, quarterly, annually, etc.)	**Projected Delivery Date(s)**	**Person(s) Responsible for Report Preparation** (title and organizational affiliation)	**Report Recipient(s)** (Project Role)
Daily Activity Reports	Daily throughout duration of field activities	Daily	Field Manager	Project Manager Project File
Weekly or Task Activity Reports	Weekly or following the completion of a field event	Within two days of the completion of a task or if a task is expected to take more than one week then a summary at the end of each week of work	Field Manager	Project Manager Project file
Data Validation Reports to be included in Final Project Report	On-going upon receipt of data deliverables	Per project schedule	Analytical Data QA Manager	Project Manager EPA Region 2 Remedial Project Manager Project file
Corrective Action Reports	Generated on the resolution of identified discrepancies in the field	Immediately upon completion	Team member identifying non-conforming activity or item Project Manager	EPA Region 2 Remedial Project Manager Project file
Final Project Report	At the completion of the assigned project tasks	Per project schedule	Project Manager	EPA Region 2 Remedial Project Manager Project file

QAPP WORKSHEET #33: QA MANAGEMENT REPORTS TABLE (CONTINUED)

Periodic QA Management reports ensure that managers and stakeholders are updated on project status and the results of all QA assessments. Efficient communication of project status and problems allows Project Coordinators to implement timely and efficient corrective actions so that the data meets the DQO requirements for the project. USEPA Region 2 will receive several types of management reports. These will include the results of any CA items and data validation reports. In addition, each report will contain a section on QA. Problems or issues that arise between regular reporting periods may be identified to program management at any time. Information included in a progress report will include but not be limited to the following:

- Results of technical systems audits conducted during the period, as applicable.
- An assessment of any problems.
- A listing of the non-conformance reports including Stop-Work Orders issued during the period, related CA undertaken, and an assessment of the results of these actions.
- Identification of significant QA problems and recommended solutions, as necessary.

Final Project Report

The issues listed in the Worksheet #33 table will be addressed in the QA management reports (as attachments to the final project report) or the QA section of the final project report. The final project report will also address additional data quality concerns, including the following:

- Narrative and timeline of project activities.
- Summary of DQO development.
- Reconciliation of project data with DQOs.
- Summary of major problems encountered and their resolution.
- Data summary, including tables, charts, and graphs with appropriate sample identification or station location numbers, concentration units, percent solids (if applicable), and data quality flags.
- Conclusions and recommendations

QAPP WORKSHEET #34: DATA VERIFICATION AND VALIDATION INPUTS

Verification Input	Description	Internal/External	Responsible for Verification
Planning Documents	Project Planning documents will be evaluated prior to implementation. Examples of items for review will include designs, specifications, health and safety procedures, and work plans in the list of reviewed items. QAPP review items will include personnel, training, laboratories, methods, SOPs, performance requirements, DQOs, forms, QAPPs, location maps, naming conventions, and project specific analytes.	I/E	Project Manager Analytical Data QA Manager Field Manager EPA Region 2 Remedial Project Manager
Field Activity Documentation	The Field Manager will review all documentation recorded by the field team during all field activities. This will include field log books, field data forms (electronic and paper), calibration records, sampling location plans, decontamination records, and daily reports.	I	Field Manager
Field Data	The data generated in the field to support the project will be checked as completed against the requirements of the Project planning documents, specific data collection requirements and applicable field SOPs. The data will be reviewed by the technical lead(s) prior to being included in the final report	I	Field Manager Leader (designated during activity)
COC Documentation	The COC documents will be peer-reviewed in the field prior to shipping of samples. The COC will also be reviewed upon receipt by the laboratory personnel and again by the data reviewers and data validation team upon receiving the analytical data packages.	I/E	Field Manager Task Leader (designated during activity) Analytical Data QA Manager Laboratory Sample Receiving personnel and Laboratory PM
CA and Non-Conformance documentation	Field CA and non-conformance reports from the laboratory will be checked as CA completed. CA taken by the laboratory will be evaluated by the Analytical Data QA Manager. CA completed by the field team will be evaluated by the Field Manager.	I	Project Manager Analytical Data QA Manager Field Manager Project QA Manager

QAPP WORKSHEET #34: DATA VERIFICATION AND VALIDATION INPUTS (CONTINUED)

Verification Input	Description	Internal/External	Responsible for Verification
Analytical Data Packages	Analytical data results will be checked as completed against the requirements of the QAPP, specific method requirements and laboratory SOPs. Analytical data packages will be reviewed by the laboratory prior to release and by the data validation team upon receipt of the data.	I	Analytical Data QA Manager
EDDs	The EDDs will be developed and provided by the laboratories. EDDs will be text files. Concentration and detection limit data will be delivered as string (as opposed to numeric) field types to ensure that the precision (i.e., number of significant digits) intended by the laboratory is represented in the EDDs. EDDs will be reviewed by the laboratory prior to release of the data and by data management and the data validation team upon receipt.	I	Field Manager Analytical Data QA Manager Laboratory Data Base Manager
Quality Control Summary Report	A summary of the laboratory QC sample results will be verified for completeness by the QA team upon receipt of data packages from the laboratory.	I	Analytical QA Manager Field Manager
Data Handling	The entry of data into the database will be evaluated for completeness and accuracy.	I	Field Manager Analytical Data QA Manager Geosyntec Database Manager

Acronym list
COC – Chain of Custody
CA - Corrective Action
DQO - Data Quality Objective
EDD – Electronic Data Deliverables
SOP – Standard Operating Procedures
QA – Quality Assurance

QAPP WORKSHEET #34: DATA VERIFICATION AND VALIDATION INPUTS (CONTINUED)

Step IIa / IIb	Data Validation Input	Description	Responsible for Data Validation
IIa	Methods	Check that the methods used were those specified by the QAPP.	Data Validation Chemist/ Geosyntec Validation Team, Field Manager
IIa/IIb	Performance Requirements	Check that the performance requirements specified by the QAPP are met.	Data Validation Chemist/ Geosyntec Validation Team, Field Manager
IIa	Report Forms	Check that the report forms are filled out completely and as required by the QAPP, method, or guidance documents.	Data Validation Chemist/ Geosyntec Validation Team, Field Manager
IIa	Sampling plans, location maps, grids, and sample ID numbers	Check that the specifications for these items were met as described by the project planning documents and work instructions.	Field Manager, Project Manager, Sampling Team peer review
IIa	SOPs (sampling and analytical)	Check that the requirements as specified by these documents were met and that the methods and SOPs referenced and contained in the QAPP were applied to the data.	Laboratory personnel, Data Validation Chemist/Geosyntec Validation Team, Field Manager
IIa	Project specific analytes	Check that the project specific analytes were reported as listed in the planning documents, specifically the QAPP.	Laboratory personnel, Technical PM, Data Validation Chemist/Geosyntec Validation Team
IIa/IIb	All required elements of the data package	Check that the required reporting elements are present in the laboratory data package.	Laboratory personnel, Data Validation Chemist/Geosyntec Validation Team

QAPP WORKSHEET #34: DATA VERIFICATION AND VALIDATION INPUTS (CONTINUED)

Step IIa / IIb	Data Validation Input	Description	Responsible for Data Validation
IIa/IIb	Sampling/Field documents	Check that the required criteria and specifications for field practices surrounding sample collection, shipping, and handling are met as specified by the project planning documents. The field documentation will be reviewed, including, but not limited to: COCs, communication logs, CA reports, documentation of field and method variances, documentation of internal QA review, EDDs review, field logs, forms, and notebook review, field calibration records, and daily field reports.	Field Manager, Project Manager
IIa/IIb	External Reports	Check that external reports created for and by the project, as applicable, such as external audit reports, laboratory assessments, performance testing results, and NELAP accreditation support the requirements of the QAPP.	Project Manager, Project QA Manager

QAPP WORKSHEET #35: DATA VERIFICATION PROCEDURES

Data Verification

During the data verification process, the laboratory data for each analytical test will be reviewed to evaluate the completeness of the data set with respect to each reference method and/or to the project requirements. This review will include the data received from the laboratory for data associated with the Operable Unit 3 groundwater investigation. Depending on the level of receivables and the stage of data validation required, these records should include the sample preparation procedure, instrument calibration data and continuing calibration data, project sample and QC sample results, sample identifications, and COCs. These records should also include the completion of the records to identify the analyst(s) who performed the testing and the dates and times of sample preparation and analysis. Depending on the level of validation required, the type of calculation may be reviewed for accuracy. It is the job of the data validator to thoroughly review the data package and to record any deviations that may have occurred. It is the responsibility of the assigned laboratory personnel to thoroughly review the data package and to record any deviations that may have occurred in the case narrative. No data will be released to Geosyntec until the internal review and approval processes are complete.

Data Review Process (Steps I, IIa, and IIb)

Prior to release of the data to Geosyntec, the analytical data will be verified by the responsible laboratory. Upon receipt of the analytical data, the data validator will perform the appropriate stage of data validation, checking the compliance, comparison and usability of the data during the data validation process.

Data Review Process Steps		Step I Verification	Step IIa Compliance	Step IIb Comparison	Step III Usability
Planning Documents					
1	Evidence of required approval of plan (QAPP)	X			Uses Outputs from Previous Steps
2	Identification of personnel (those involved in the project and those conducting verification steps)	X			
3	Laboratory Name	X			
4	Methods (sampling and analysis)	X	X		
5	Performance requirements (including QC criteria) for all inputs	X	X	X	
6	Project quality objectives	X	X	X	

QAPP WORKSHEET #35: DATA VERIFICATION PROCEDURES (CONTINUED)

Data Review Process Steps		Step I Verification	Step IIa Compliance	Step IIb Comparison	Step III Usability
Planning Documents (continued)					
7	Reporting forms	X	X		Uses Outputs from Previous Steps
8	Sampling plans, location, maps, grids, and sample ID numbers	X	X		
9	Site identification	X	X		
10	SOPs (sampling and analytical)	X	X		
11	Staff training and certification	X	X		
12	List of project-specific analytes	X	X		
Analytical Data Package					
13	Case narrative	X	X		Uses Outputs from Previous Steps
14	Internal laboratory COC	X	X		
15	Sample condition upon receipt, and storage records	X	X		
16	Sample chronology (time of receipt,	X	X		
	extraction, and analysis				
17	Identification of QC samples (sampling or lab, temporal, and spatial)	X	X		
18	Associated (batch or periodic) PT sample results	X	X	X	
19	Communication Logs	X	X		
20	Copies of laboratory notebook, records, prep sheets	X	X		
21	CA Reports	X	X		
22	Definitions of laboratory qualifiers	X	X	X	
23	Documentation of laboratory method deviations	X	X	X	
24	Documentation of individual QC results (e.g., spike, duplicate, LCS)	X	X	X	

QAPP WORKSHEET #35: DATA VERIFICATION PROCEDURES (CONTINUED)

	Data Review Process Steps	Step I Verification	Step IIa Compliance	Step IIb Comparison	Step III Usability
Analytical Data Package (continued)					
25	Documentation of laboratory method deviations	X	X	X	Uses Outputs from Previous Steps
26	EDDs	X	X		
27	Instrument Calibration Reports	X	X	X	
28	Laboratory name	X	X		
29	Laboratory sample identification numbers	X	X		
30	QC sample raw data	X	X	X	
31	QC summary report	X	X	X	
32	Raw data	X	X	X	
33	Reporting forms, completed with actual results	X	X	X	
34	Signatures for laboratory sign-off (e.g., laboratory QA/QC Manager)	X	X		
35	Standards traceability records (to trace standard source from National Institute of Standards and Technology (NIST), for example; completed during Stage 4 data validation)	X	X	X	
Sampling Documents					
36	COC	X	X		Uses Outputs from Previous Steps
37	Communication Logs	X	X		
38	CA results	X	X		
39	Documentation of CA results	X	X	X	
40	Documentation of deviation from methods	X	X	X	
41	Documentation of internal QA review	X	X	X	
42	EDDs	X	X		
43	Identification of QC samples	X	X	X	

QAPP WORKSHEET #35: DATA VERIFICATION PROCEDURES (CONTINUED)

Data Review Process Steps		Step I Verification	Step IIa Compliance	Step IIb Comparison	Step III Usability
Sampling Documents (continued)					
44	Meteorological data from field (e.g., wind, temperature)	X	X	X	Uses Outputs from Previous Steps
45	Sampling instrument decontamination records	X	X		
46	Sampling instrument calibration logs	X	X		
47	Sampling Location and Plan	X	X	X	
48	Sampling notes and drilling logs	X	X	X	
49	Sampling report (from Field Manager to Project Manager describing sampling activities)	X	X	X	
External Reports					
50	External audit report	X	X	X	Uses Outputs from Previous Steps
51	External proficiency testing sample results	X	X		
52	Laboratory certification	X	X		
53	Laboratory QA plan	X	X		
54	MDL study information	X	X	X	
55	NELAP accreditation	X	X		

QAPP WORKSHEET #36: DATA VALIDATION PROCEDURES

Step IIa / IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria	Data Validator (title and organizational affiliation)
IIa/IIb	Groundwater	Analyses listed in WS#15 of this QAPP	Low/Standard	Criteria cited in the QAPP, method and SOP criteria, current National Functional Guidelines for Data Validation, and EPA Region 2 Quality Assurance Guidance and Standard Operating Procedures. Definitive data are required for the EPA approved analytical tests used for measuring groundwater, at the site.	Data Validation Chemist/Geosyntec Validation Team

Data Validation

Stage 2A data validation will be performed manually on 90% of the data associated with the remedial investigation and risk assessment, with the remaining 10% validated at Stage 4. During data validation, the evaluation of the data will extend beyond method, procedural, or contractual compliance (verification) to check the analytical quality of the specific data set. The data will be evaluated with regard to compliance with the DQOs and measurement quality objectives. During data validation, data validation qualifiers will be assigned to provide the basis of describing data quality. Should non-conformance issues be generated from the laboratory, the data validation procedure evaluates the impacts of the nonconformance(s) on the quality and usability of the data set.

Step IIa denotes a list of data validation activities which include the following and are associated with methods, procedures, and contracts (MPC):

- Data Deliverables – Check that the required information on sampling and analysis are provided.
- Analytes – Check that the appropriate analytes were reported, as required.
- COC – Evaluate traceability of data and examine against procedural requirements.
- Holding times – Check analysis holding times.

QAPP WORKSHEET #36: DATA VALIDATION PROCEDURES (CONTINUED)

- Sample Handling – Check that sample preservation, handling, and storage procedures were met.
- Analytical Methods and Procedures – Evaluate whether the required methods and procedures were performed.
- Data Flags – Check that the laboratory flags were defined and used correctly.
- Laboratory Transcription – Check accuracy of transcription, where applicable.
- Standards – Check that standards are traceable and meet project and contract requirements; this is completed as part of Stage 4 data validation.

Step IIb denotes a list of data validation activities which include the following and are associated with comparison with MPC in the QAPP:

- Data Deliverables and QAPP – Check that data report from Step IIa was provided.
- Field Duplicates – Compare results of field duplicates with criteria established in the QAPP.
- Project Quantitation Limits – Check that quantitation limits were achieved as outlined in the QAPP. As part of Stage 4 data validation, check that the laboratory successfully analyzed a standard at the quantitation limit.
- Confirmatory Analysis – Evaluate the agreement of the laboratory results, as appropriate.
- Performance Criteria – Evaluate QC data against project specific performance criteria in the QAPP (i.e., evaluate quality parameters beyond those outlined in the methods).
- Data Qualifiers – Check that the data validation qualifiers applied in Step IIa were those specified in the QAPP and that any deviations were specified.
- Step IIb Data Validation Report – Summarize outcome of comparison of data to MPC in the QAPP, and include qualified data and explanation of the data qualifiers.

QAPP WORKSHEET #37: DATA USABILITY ASSESSMENT

To the extent possible, Geosyntec will follow EPA's data quality assessment (DQA) process to verify that the type, quality, and quantities of data collected are appropriate for their intended use. DQA methods and procedures are outlined in USEPA QA/G9-R Data Quality Assessment, A Reviewer's Guide, February 2006. The DQA process includes five steps: 1) review the DQOs and sampling design; 2) conduct a preliminary data review; 3) select a statistical test; 4) verify the assumptions of the statistical test; 5) draw conclusions from the data.

After the data are received from the fixed based laboratory, data validation of the data will occur as described in Worksheet #36. During data validation, where necessary, data validation qualifiers will be applied to the data indicating that it has limited use, should perhaps be examined more closely, or has dramatically failed one or more data quality indicator criteria and has been rejected. This information will be supplied to the project team via a data validation report and to the data manager through updates to the database. A DQA report will be prepared on a periodic basis summarizing the overall quality of the data including field data, field QC data, laboratory QC data, and laboratory data. This will further illustrate the limitations of any qualified data that may have resulted during data validation.

It is incumbent on the project team to then utilize the data in an appropriate manner based on any limitations that have been identified.

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used:

Data usability is the process of evaluating the data validation results and determining the confidence with which any data point(s) may be used. Usability is determined by evaluating the data validation qualifier applied and the laboratory QC results. Concentration values may be considered to have a high degree of confidence because the associated method performance criteria were achieved. Estimated concentration results are evaluated with respect to the bias contributed to the value by the associated QC result. Bias direction can be estimated for data quality impacts due to surrogate recoveries, MS recoveries, and LCS recoveries. Sample concentration results that are rejected during data validation are not used in the decision-making process and should not be reported.

Describe the evaluative procedures used to assess overall measurement error associated with the project:

Data usability is evaluated with respect to the DQOs developed in this QAPP to check that the opportunity for incorporating unacceptable and manageable error into the decision-making process is minimized to the extent possible. The DQOs for this project are described in Worksheet #11.

The analytical data, data validation qualifiers, and QC results will be evaluated to determine the confidence with which the analytical data can be used in the project decision-making process. The criteria used in the data usability summary are presented as follows using the data quality indicator criteria required for this project and measured as precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS).

QAPP WORKSHEET #37: DATA USABILITY ASSESSMENT (CONTINUED)

PARCCS Overview

Introduction

This QA program addresses both field and laboratory activities. QA objectives are formally measured through the computation of performance measures known as data quality indicators (DQIs), which are in turn compared to pre-defined measurement quality objectives (MQOs) specific to the project objectives. The DQIs for measurement data are expressed in terms of PARCCS. Evaluation of DQIs provides the mechanism for on-going control and evaluation of data quality throughout the project and ultimately will be used to define the data quality achieved for the various measurement parameters. The field QA program will be accomplished through the collection of QC samples such as field duplicates and trip blanks. The analytical QA program will be assessed through the internal laboratory QC performed, including method blanks, laboratory control sample (LCS) recoveries, surrogate recoveries, and matrix spike/matrix spike duplicate (MS/MSD) recoveries. The following sections describe the DQIs in greater detail, with a discussion of the associated MQOs.

Precision

Precision refers to the reproducibility or degree of agreement among duplicate measurements of a single analyte. The closer the numerical values of the measurements, the more precise the measurement. Poor precision stems from random errors (i.e., mechanisms, which can cause both high and low measurement errors at random). Precision is usually stated in terms of relative percent difference (RPD), but other estimates, such as the relative standard deviation (RSD), range (maximum value minus minimum values), and relative range are common, and may be used pending review of the data.

Precision will be checked through the collection of field duplicates and the analysis of MS/MSD and LCS/LCSD samples for the work performed at the Site. The overall precision of measurement data is a mixture of sampling and analytical factors. Analytical precision is much easier to control and quantify than sampling precision; there are more historical data related to individual method performance, and the “universe” is not limited to the samples received in the laboratory. In contrast, sampling precision is unique to the project. Sampling precision will be measured through the laboratory analysis of field duplicate samples. Laboratory precision will be measured through the analysis of MS/MSD and LCS/LCSD samples.

QAPP WORKSHEET #37: DATA USABILITY ASSESSMENT (CONTINUED)

During the collection of data using field methods and/or instrumentation, precision is checked by reporting several measurements taken at one location and comparing the results. Precision will be determined from duplicate samples and will be expressed as the RPD between replicate/duplicate sample results, computed as follows:

$$RPD = \frac{X_1 - X_2}{(X_1 + X_2)/2} \, x \, 100$$

where *X1* and *X2* are reported concentrations for each replicate sample and subtracted differences represent absolute values. For field duplicates, the precision goal for this project is an RPD of 30%. For laboratory duplicates, the RPD goals are dictated by the specific analytical and laboratory QC acceptance criteria.

Accuracy and Bias

Accuracy refers to the degree of difference between measured or calculated values and the true value. The closer the numerical value of the measurement comes to the true value, or actual concentration, the more accurate the measurement. The converse of accuracy is bias, in which a systematic mechanism tends to consistently introduce errors in one direction or the other. Bias in environmental sampling can occur in one of three ways; these mechanisms and their associated diagnostic and management methods are as follows:

- High bias, which can stem from cross-contamination of sampling, packaging, or analytical equipment and materials. Cross- contamination is monitored through blank samples, such as equipment blanks, trip blanks, and method blanks. These samples assess the potential for cross-contamination from, respectively, sampling equipment, ambient conditions, packaging and shipping procedures, and laboratory equipment. Data validation protocols described in Worksheet #36 present a structured approach for data qualification based on blank samples.
- Low bias, which can stem from the dispersion and degradation of target analytes (e.g., volatilization of chlorinated solvents during field sampling). The effects of these mechanisms are difficult to quantify. Sampling accuracy can be maximized, however, by the adoption and adherence to a strict field QA program. Specifically, sampling procedures will be performed following standard protocols described in the QAPP. Through regular review of field procedures, deficiencies will be documented and corrected in a timely manner.
- High or low bias may occur due to unacceptable recoveries, unacceptable calibration, or other system control problems. The effects of these mechanisms on analytical accuracy may be expressed as the % recovery of an analyte that has been added to the environmental sample at a known concentration before analysis. Analytical accuracy in the laboratory will be determined through the analysis of LCS/LCSDs and MS/MSDs. As with blank samples, data validation protocols provide a structured formula for data qualification based on high or low analyte recoveries.

QAPP WORKSHEET #37: DATA USABILITY ASSESSMENT (CONTINUED)

Accuracy goals are presented as upper and lower control limits for percent recovery and are generated through the compilation of control charts and referenced in each laboratory method SOP.

Representativeness

Representativeness is defined by the degree to which the data accurately and precisely describe a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. If the results are reproducible, the data obtained can be said to represent the environmental condition. Representativeness is evaluated by collecting sufficient numbers of samples of an environmental medium, properly chosen with respect to place and time. The precision of a representative set of samples reflects the degree of variability of the sampled medium, as well as the effectiveness of the sampling techniques and laboratory analysis.

Completeness

Completeness is defined as the percentage of measurements made which are judged to be valid measurements. The completeness goal is essentially the same for all data uses in that sufficient amounts of valid data are to be generated.

There are limited historical data on the completeness achieved by individual methods. However, the Contract Laboratory Program data have been found to be 80 to 85% complete on a nationwide basis. The percent completeness for each set of samples will be calculated as follows:

$$\%\ Completeness = \frac{Valid\ Data}{Total\ Data\ Planned}\ x\ 100$$

The QA objective for completeness for all parameters will be 90%.

Comparability

Comparability expresses the confidence with which one data set can be compared to another data set measuring the same property. Comparability is evaluated through the use of established and approved analytical methods, consistency in the basis of analysis (e.g., wet weight, volume), consistency in reporting units (µg/L, mg/L), and analysis of standard reference materials. By using standard sampling and analytical procedures, data sets will be comparable.

Sensitivity

Sensitivity refers to the minimum magnitude at which analytical methods can resolve quantitative differences among sample concentrations. If the minimum magnitude for a particular analytical method is sufficiently below an action level or risk screening criterion, then the method sensitivity is deemed sufficient to fully evaluate the dataset with respect to the desired reference values. Frequently, risk-based screening levels fall below the sensitivity of even the most sensitive analytical methods. In such cases, it is necessary to review the qualifications of several laboratories, both from the standpoint of sensitivity as well as other DQIs, to select the best laboratory for the project.

QAPP WORKSHEET #37: DATA USABILITY ASSESSMENT (CONTINUED)

The method detection limit (MDL) is a theoretical limit determined through an MDL study, in which the concentration of a spiked solution is analyzed at least seven times. The standard deviation of the recovered concentrations (σrec) is computed and multiplied by the t-distribution value to arrive at the MDL. Method blank results are also used in the MDL calculations. In practice, to allow for matrix interferences variability in instrument control, a reporting limit of 2.5 to 5 times the MDL is typically selected. The reporting limit (RL) used for each analyte must be supported by an initial calibration that incorporates one or more calibration standards with the concentrations at or below the reported RL.

Analytical sensitivity is readily evaluated by comparing method reporting limits to risk-based screening values. The results of this analysis are presented in Worksheet #15, which demonstrate the suitability of the selected methods to the project requirements.

Identify the personnel responsible for performing the usability assessment:

Data usability is first evaluated by the data validation team, the analytical quality assurance manager, and the laboratory performing the fixed base analysis. Usability of data collected in the field is first determined by the field team and Field Manager. Once the data are validated the usability of the data are determined by the project team, specifically the technical leaders for the project and the Project Manager.

Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

Data usability will be documented through validation reports as well as through the issuance of data quality assessment reports (DQARs), which will summarize how the data reflect the specific criteria for the data quality indicators assigned to the project.